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INTRODUCTION.

As explained in this Introduction during 1914, the MONTHLY WEATHER REVIEW now takes the place of the Bulletin of the Mount Weather Observatory and of the voluminous publication of the climatological service of the Weather Bureau. The MONTHLY WEATHER REVIEW contains contributions from the research staff of the Weather Bureau and also special contributions of a general character in any branch of meteorology and climatology.

SUPPLEMENTS to the MONTHLY WEATHER REVIEW will be published from time to time.

The climatological service of the Weather Bureau is maintained in all its essential features, but its publications, so far as they relate to purely local conditions, are incorporated in the monthly reports of climatological data for the respective States, Territories, and colonies.

Since December, 1914, the material for the MONTHLY WEATHER REVIEW has been prepared and classified in accordance with the following sections:

SECTION 1.—*Aerology.*—Data and discussions relative to the free atmosphere.

SECTION 2.—*General meteorology.*—Special contributions by any competent student bearing on any branch of meteorology and climatology, theoretical or otherwise.

SECTION 3.—*Forecasts and general conditions of the atmosphere.*

SECTION 4.—*Rivers and floods.*

SECTION 5.—*Seismology.*—Results of observations by Weather Bureau observers and others as reported to the Washington office. Occasional original papers by prominent students of seismological phenomena.

SECTION 6.—*Bibliography.*—Recent additions to the Weather Bureau library; recent papers bearing on meteorology.

SECTION 7.—*Weather of the month.*—Summary of local weather conditions; climatological data from regular Weather Bureau stations; tables of accumulated and excessive precipitation; data furnished by the Canadian Meteorological Service; monthly charts Nos. 1, 2, 3, 4, 5, 6, 7, 8, the same as hitherto.

In general, appropriate officials prepare the seven sections above enumerated; but all students of atmospherics are cordially invited to contribute such additional articles as seem to be of value.

The voluminous tables of data and text relative to local climatological conditions that during recent years were prepared by the 12 respective "district editors," are omitted from the MONTHLY WEATHER REVIEW, but collected and published by States at selected section centers.

The data needed in Section 7 can only be collected and prepared several weeks after the close of the month whose name appears on the title page; hence the REVIEW as a whole can only issue from the press within about eight weeks from the end of that month.

It is hoped that the meteorological data hitherto contributed by numerous independent services will continue as in the past. Our thanks are specially due to the directors and superintendents of the following:

The Meteorological Service of the Dominion of Canada.
The Central Meteorological and Magnetic Observatory of Mexico.
The Director General of Mexican Telegraphs.
The Meteorological Service of Cuba.
The Meteorological Observatory of Belen College, Habana.
The Government Meteorological Office of Jamaica.
The Meteorological Service of the Azores.
The Meteorological Office, London.
The Danish Meteorological Institute.
The Physical Central Observatory, Petrograd.
The Philippine Weather Bureau.

SECTION 1.—AEROLOGY.

SOLAR AND SKY RADIATION MEASURED AT WASHINGTON, D. C., DURING APRIL, 1915.

By Herbert H. Kimball, Professor of Meteorology.

[Dated: Washington, D. C., May 29, 1915.]

In Table 1 are summarized the measurements of the intensity of direct solar radiation made by the Weather Bureau at the American University,[1] Washington, D. C., during April, 1915. The means for the month show only slight departures from the 5-year means published in the Bulletin of the Mount Weather Observatory, 1912, **5** : 182, Table 3. The measurements obtained previous to noon of the 18th were generally above the normal, and after that time were decidedly below normal.

Table 1.—*Solar radiation intensities at Washington, D. C., during April, 1915.*

[Gram-calories per minute per square centimeter of normal surface.]

Date.	Sun's zenith distance.										
	0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°	80.7°
	Air mass.										
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
1915. A. M.	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*
Apr. 1			1.22	1.16	1.07	1.00	0.93	0.88	0.83	0.79	0.73
8	1.50	1.34	1.20	1.10	1.01	0.92	0.84	0.77	0.71	0.66	
9		1.00	0.82	0.74							
13			1.20	1.10	1.01	0.93	0.86	0.81	0.77	0.72	0.68
14	1.45	1.37	1.27	1.17	1.07	0.97		0.82	0.77	0.72	0.68
15	1.39										
16		1.16	1.08	0.96	0.86	0.80	0.74	0.68	0.62	0.57	
18	1.49	1.32	1.24	1.14	1.06	0.98					
26	1.16	0.88	0.72	0.63	0.54						
30		1.07	0.90								
Means	**1.40**	**1.16**	**1.07**	**1.00**	**0.95**	**0.93**	**0.84**	**0.79**	**0.74**	**0.69**	**0.70**
P. M.											
Apr. 4	1.54	1.37	1.21	1.10	1.02	0.94	0.88				
14			1.20	1.09	1.00	0.91					
15						0.84	0.77	0.70	0.61		
18		1.16	0.88								
30	1.16	1.03					0.46	0.40	0.36		
Means	**(1.35)**	**1.19**	**1.10**	**(1.10)**	**(1.01)**	**0.90**	**0.70**	**(0.55)**	**(0.48)**		

Skylight polarization, measured at solar distance 90° and in the sun's vertical, with the sun at zenith distance 60°, averaged 58 per cent, with a maximum of 67 per cent. This latter is 4 per cent higher than the average maximum for April published in the Bulletin of the Mount Weather Observatory, **3** : 114, Table 16.

In Table 2, column 2 gives the daily totals of solar and sky radiation received on a horizontal surface at the American University. The measurements were made with a Callendar recording pyrheliometer as described in the Review for March, 1915, **43** : 100. Table 2, column 3, gives the departures from the daily normals published in the same number of the Review, page 107, Table 4.

The above data show less than the average cloudiness, more than average sunshine, and solar radiation above the average in intensity during April, 1915, but especially so during the first two decades of the month.

Table 2.—*Daily totals and departures of solar and sky radiation at Washington, D. C., during April, 1915.*

[Gram-calories per square centimeter of horizontal surface.]

Date.	Daily total.	Departure from normal.	Excess or deficiency since first of month.	Percentage of possible sunshine.	Average cloudiness.
1915.	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Per cent.*	*0-10.*
Apr. 1	573	197	197	100	0
2	429	51	248	66	8
3	77	−304	− 56	0	10
4	567	184	128	95	2
5	324	− 61	67	66	9
6	387	− 1	66	70	5
7	512	122	188	84	3
8	601	208	396	100	0
9	463	67	463	85	6
10	446	48	511	72	7
11	129	−272	239	15	9
12	502	98	337	73	5
13	552	145	482	100	2
14	634	224	706	100	0
15	615	202	908	100	0
16	456	38	946	69	5
17	384	− 39	907	64	6
18	640	212	1,119	100	0
19	521	88	1,207	100	4
20	420	− 18	1,189	73	7
Decade departure.			**678**		
21	561	118	1,307	100	2
22	278	−170	1,137	23	9
23	395	− 58	1,079	52	8
24	425	− 33	1,046	76	4
25	515	52	1,098	100	0
26	504	36	1,134	74	4
27	399	− 74	1,060	70	4
28	494	16	1,076	66	6
29	435	− 48	1,028	43	7
30	610	122	1,150	85	1
Decade departure.			**− 39**		
Total excess since first of year.			**909**		

[1] For a description of exposures of instruments and details of methods of observation, see this Review, December, 1914, 42 : 648.

SECTION II.—GENERAL METEOROLOGY.

THE ORIGIN OF THE WIND.

By J. W. SANDSTRÖM.

[Dated: Stockholm, Feb. 27 and Apr. 15, 1915.]

1. On careful consideration it appears that the wind plays a rôle of fundamental importance for the earth and all life upon it. Without the wind no cloud can be brought to land; no precipitation would fall upon the earth; no rivers would exist. The mountains, indeed, in consequence of the hot sunshine would weather down but no brooks or rivers would remove the weathered fragments. Thus without the action of the wind the earth's surface would take on an appearance entirely different from what it now has. Its absence would also threaten the existence of organic life. Plants and animals would indeed be able to exist in the seas, but this would be impossible on the absolutely arid land surfaces. Man on a dry earth is an inconceivable combination.

The energy that forms the living force of the wind, and of which we use an infinitessimal part in order to drive our ships and windmills, has of course originally come to the earth as heat from outside. This outside heat is then transformed into the energy of motion or kinetic energy, in the same way that heat is transformed into kinetic energy in a steam engine.

2. In a steam engine there is a source of heat, viz, the boiler, and a source of cold, viz, the condenser. In the atmosphere the broad ocean with its warm surface water is the source of heat, while the mountains and the ice cover of Greenland and the icy Antarctic continent are the sources of cold. The wind originates between these regions of opposite climatic characteristics.

3. In order to understand how this is brought about I have carried out the following experiment. A large glass-sided tank 50 cm. by 50 cm. by 5 cm. was filled with water. Two sets of metallic cells, similar to the heating coils of our dwellings, were then suspended in this tank. Hot water passed through one set of these cells and cold water through the other. The feed and discharge pipes were carefully insulated against heat, and the flow of warming or cooling water was maintained by the difference in level between the water supplies contained in two pairs of large wooden vats of considerable volume and capacity for heat. The temperature differences used in the cells were small but constant.

4. Like all experiments with heat, these were very tedious. First, the water in the glass experimental tank had to stand for two days, that it might assume the temperature of the room as closely as possible. Then the experiment was started and its conditions maintained for several hours until well established. Only after attaining this established condition was the next step taken, viz, the insertion of a small quantity of potassium permanganate which revealed the movements of the water under the strong illumination of an arc light. This enabled one to measure the circulation that had been established.

5. The results of the experiment were as follows: If the source of heat (the warm coil) stood at the same level as the cold source, then the water stood still; but as soon as the warm coil was lowered there began a circulation whose intensity was in proportion to the increase in the difference in level between the warm source and the cold source.

6. This result, although it is so simple, is nevertheless of the greatest importance for a correct understanding of the atmospheric processes. If the sources of warm and cold in the atmosphere are at the same level, they then induce no wind; precisely as a steam engine can perform no work when the pressure in the boiler is equal to the pressure in the condenser. The extensive [cold] ice surfaces of the North Polar Ocean can, therefore, produce no wind because they are at the same level as that of the warm ocean to the south. For the same reason the Siberian tundra, although it is cold enough, does very little to produce and maintain the wind. On the other hand, the high extensive ice-covered surface of Greenland produces far more wind than has been heretofore suspected. On this glacier is really the place where a first-order meteorological station should be established, preferably on the southeast side, which slopes toward the warm Atlantic Ocean. Here we find a gigantic heat engine which is only exceeded by the corresponding one on the border of Antarctica.

7. In the Northern Hemisphere there are, besides Greenland, many mountain chains and high plateaus whose contributions to the wind should not be underestimated. For example, the Pyrenees, the Alps, the Carpathians, and also the Scandinavian highlands, whose location as antagonistic to the Gulf Stream give rise to the European storms of winter. In Asia, the monsoon arises from the contrast between the Himalayas and the high Thibetan Plateau on the one hand and the warm Indian Ocean on the other.

8. The conditions in the Southern Hemisphere are specially grand and simple. In the coastal region of Antartica, during the Antartic winter, exist powerful and continuous winds, evidently caused by the extensive high cold surface of the continent in contrast with the surface of the warm surrounding ocean. Here is found the incomparably largest wind factory on our planet.

9. We may now return to the experimental tank, limiting ourselves to a case where the cold source stands at a higher level than the warm source. After introducing the permanganate of potash into the center of the tank, as described in **4**, the color is rapidly drawn around so that a continuous band of colored water is produced, as represented in figure 1. The color then encroaches more and more upon the still uncolored region within the continuous colored band, until eventually there remains only a narrow streak which extends from *W*, the source of heat, to *C*, the source of cold. This stage is shown in figure 2. This inclined streak becomes steadily thinner and gradually passes into a surface which also eventually becomes completely colored and finally disappears.

10. The tank now shows two sharply marked level surfaces, one of which passes through the highest point of the cold source and the second passes through the lowest point of the warm source. These surfaces divide the mass of water into three strata, an uncolored superficial layer, the colored intermediate layer, and the uncolored bottom layer. From the circumstance that no color passes over from the intermediate layer into either of the two uncolored layers, whereas the latter

remain clear, we conclude that there is no interchange of water between them and the intermediate layer. The three strata of water are wholly insulated from one another.

11. We have already discovered that the intermediate layer is in more or less rapid circulation, as indicated by the arrows in figures 1 and 2. By introducing permanganate of potash into the superficial and the bottom layers we can establish the fact that the water is there standing still.

12. The distribution of temperature within the tank is now investigated by dipping into it a small thermometer on a delicate thread, placing the bulb at different depths and reading the temperatures through the glass sides of the tank. We thus find that the bottom layer has the temperature of the cold source and that the superficial layer has the temperature of the warm source, while there are two temperatures in the intermediate or colored stratum. In this stratum the water below the inclined streak of figure 2 is colder than the colored water above the streak. The two horizontal level surfaces and also the inclined streak are all characterized by marking sharp changes of temperature. There are, therefore, four thermally different layers of water in the tank under these conditions; the layers are so arranged that warmer water always rests upon colder water.

13. Since the density of the water can in this case only depend upon its temperature, therefore so far as density is concerned there must also be four different layers of water in the tank, and they are so arranged that the lighter water always rests upon the heavier (the less dense upon the more dense). Where sudden changes in temperature occur there also must be sudden changes in density, i. e., the isosteric surfaces must there mutually converge. In the two level boundary surfaces the isosteric surfaces lie horizontally; that is, they are there parallel with the horizontal isobaric surfaces. These two systems of surfaces do not there mutually intersect and therefore form no solenoids. The inclined isosteric surfaces that lie along the inclined streak, on the other hand, intersect the isobaric surfaces thereby giving rise to a system of solenoids that is localized in the inclined streak. In this streak, therefore, lies the driving source of the whole water motion in the tank.

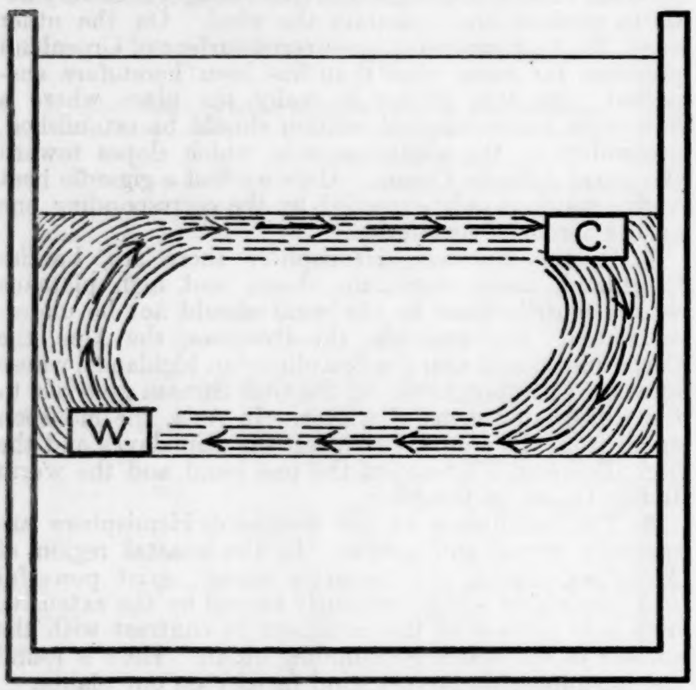


FIG. 1.—Cross section of glass-sided experimental tank showing the circulation set up by the cold cell, *C*, and the warm cell, *W*, as revealed shortly after introducing the permanganate of potash. Above *C* and below *W* are the regions of clear, unaffected, quiescent water. The region lying between *C* and *W* has not yet been stained by the permanganate.

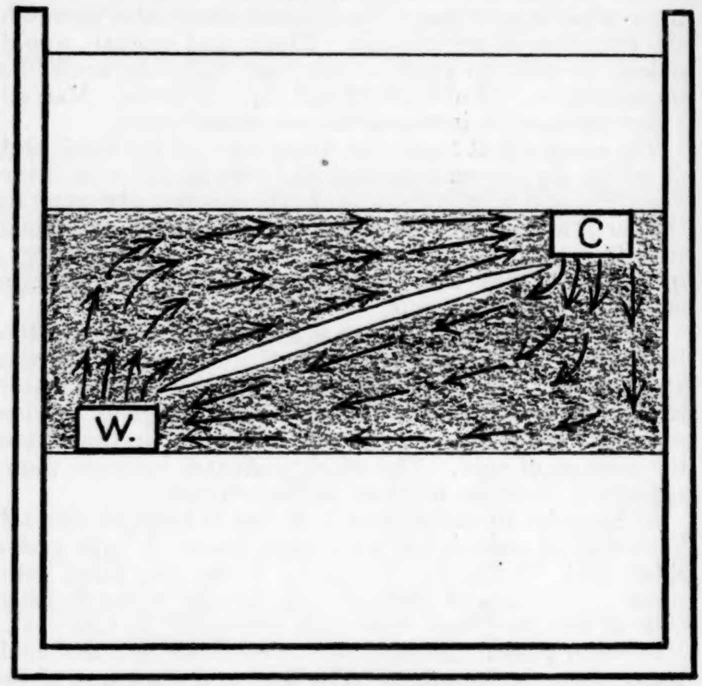


FIG. 2.—The same cross section of the tank after a further lapse of time. The unshaded, spindle-shaped area lying obliquely between *W* and *C* is the immediate predecessor of the inclined solenoidal streak or surface. Above *C* and below *W* remain the uncolored regions of unaffected, quiescent water.

14. If we compare the heat engine represented by the arrangements of figure 2 with a steam engine, then W corresponds to the engine boiler, C to the condenser, and the driving mechanism of the engine is the inclined streak.

15. In order to compute the energy developed by the heat engine of figure 2 it is necessary to introduce into a system of pressure-and-volume coordinates, the various conditions experienced by a particle of water during a complete circulation of the whole mass of water. The resulting curve of condition incloses a surface equal to the energy, A, developed by a gram of water in making one complete circuit. When A is multiplied by the total mass, M, of the water in circulation the product is the total energy developed in making one complete circuit. If T seconds are required for the whole mass, M, to make one circuit, then the quantity of energy, E, that is delivered per unit of time is

$$E = \frac{MA}{T}. \tag{1}$$

16. But the quotient M/T is equal to the quantity of water, m, that flows through any given section of the stream in one second; hence

$$E = mA, \tag{2}$$

and A is nothing else than the number of solenoids that are in the inclined streak. The energy delivered by the heat engine in figure 2 is, therefore, equal to the flowing mass of water expressed in grams per second multiplied by the number of Bjerknes solenoids in the inclined streak.

17. The above formulas express the energy in absolute units; a horsepower contains 736×10^7 of these units. Therefore

$$P = \frac{mA}{736 \times 10^7} \qquad (3)$$

where P is the developed energy expressed in horsepowers. In the atmosphere and the ocean problems it is more convenient to employ tons instead of grams; therefore we write

$$P = \frac{NA}{7360}\text{HP}. \qquad (4)$$

where N is the mass of moving air or water expressed in tons per second of the C. G. S. system. A is as before the number of solenoids in the inclined solenoidal surface or streak.

18. The circulation represented in figure 2 can also be conceived at two different currents of water; the one current consisting of cold, specifically heavier water that flows down from the cold source toward the warm source; the other current of warm, lighter water that rises from the source of heat and flows toward the source of cold. There are, in fact, two actual waterfalls, the one of denser water that sinks and the other of lighter water that rises. Both these falls develop kinetic energy in the same way as do the waterfalls of our rivers. The only difference is that, instead of the total specific gravity of the water of the river computation, we here have to employ the difference in specific gravity between the flowing and the surrounding, adjacent water. This is a natural consequence of the Archimedean principle of pressure of adjacent surrounding water against the flowing water. Employing the thus reduced specific gravity, the actual height of the waterfall, and the stream discharge, the computation of the energy gives the same result as does the solenoidal formula.

19. One can also compute the correct amount of developed energy by employing the actual specific gravity and the height of the waterfall if a corresponding reduction is applied to the mass of the flowing water; or we may use the actual specific gravity and the stream discharge in combination with an appropriately reduced height of waterfall. I have found the last of these procedures the most practical because that method permits the direct substitution of tons of flowing water or air for the cubic meters of water of the river they are compared with.

20. In the atmosphere, the snow and ice covered mountain tops and high plateaus correspond with the cold source C of figure 2, and the warm surface water of the warm ocean with its warm currents correspond with the warm source W. The circulation of the air that exists in the atmosphere is of the same kind and nature as the circulation of the water shown in figure 2. Thus the air warmed above the warm surface of the ocean rises and spreads out horizontally until it comes in contact with the cold mountain tops. Here it cools, sinks, and returns along the earth's surface to the warm ocean only to repeat the circulatory process. The warm current of air above and the cold current below are separated by an inclined surface corresponding to the inclined streak of figure 2. This atmospheric surface contains the solenoids that induce and maintain the atmospheric circulation. The amount of kinetic energy developed by the two air currents can be estimated according to the manner above described, either employing formula (4) or by comparing the currents with the waterfalls.

21. The circulation of the water in the atmosphere is also like the scheme of figure 2. In this case the source of heat is the warm ocean surface whose water particles evaporate and rise in a gaseous form into the atmosphere; the cold source, C, is the point in the atmosphere where the water vapor is cooled and condensed into rain or snow. These forms fall and form rivers that flow back to the ocean, i. e., back to the source of heat W. In this circulation an immense amount of kinetic energy is produced—of it we use a very small fraction in our hydroelectric and water-power plants. The largest part of the energy of this circulation is consumed in producing the wind, as the Swedish oceanographer, Prof. Otto Peterson, has shown. The computation of this energy by the above methods offers no special difficulties.

22. The ocean currents also appear to follow the scheme of figure 2. Let us consider, for instance, the Gulf Stream. It has its origin in the great sargasso vortex which carries the sun-warmed ocean water of the Tropics downward to a depth of 600 meters. This is the source of heat W, of the Gulf Stream. From here the warm Gulf Stream water flows along the Atlantic trough northward until it reaches the ice of the Arctic Ocean. This ice corresponds to the cold source C of figure 2; it cools the Gulf Stream water which sinks to the depths along which it flows back as a cold undercurrent toward W in the Tropics. Here it is again warmed, rises to the surface, and again wanders northward. On its northward course the upper portion of the Gulf Stream becomes shallower; under the Tropics it is 600 meters deep but at Spitzbergen it is only 200 meters deep. The surface dividing the warm upper stream from the cold undercurrent is therefore inclined like the sloping streak of figure 2; therefore, this streak contains a number of solenoids, amounting to about 150,000, according to hydrographic observations. The mass of water that flows in the Gulf Stream is estimated at 25,000,000 cu. m. per second. Therefore, and by equation (4), the Gulf Stream delivers about 500,000,000 HP. This amount of energy is, of course, applied to the task of driving the Gulf Stream itself, whereby the internal friction of the water reconverts it into heat. The Gulf Stream may be compared to a river that discharges 25,000,000 cu. m. per second over a waterfall 1½ meters high. Such a waterfall would develop the same amount of energy as does the Gulf Stream.

23. In order to be able to make such numerical estimates of the energy of the atmospheric currents we must have the proper data at appropriately located mountain stations and kite stations.

24. For the present we see from the foregoing that the simple experiment presented in figure 2 possesses many large and important counterparts in the atmosphere and the hydrosphere. Indeed, it can hardly be otherwise since it is itself a picture in miniature of the powerful heat engine that creates the currents of the wind and the ocean.

SOME RECENT RESEARCHES ON THE MOTION OF FLUIDS.

By HARRY BATEMAN, M. A., Ph. D.

[Dated: Johns Hopkins University, Baltimore, Apr. 26, 1915.]

1. The early attempts of mathematicians to calculate the distribution of velocity in a fluid containing a solid body either at rest or in motion, led to conclusions which do not agree with experimental results.

In the continuous potential flow of a perfect fluid it was found, for instance, that a fluid of infinite extent offers no resistance to uniform motion of the body, pro-

vided the motion of the fluid is steady. This is the so-called *paradox of d'Alembert* (1). The result is contradicted by experience, although it should be remembered that for a spindle-shaped body of stream-line form the resistance is very small (2) and in actual experiments the fluid either has a free surface or is inclosed in a vessel of finite size.

The assumption that the velocity is everywhere continuous also led to the conclusion that fluid issuing from the mouth of a tube immediately spreads out in all directions (3), whereas in reality the fluid forms, at all events for some distance, a more or less compact stream. In 1847 Stokes (4), while discussing the motion of a fluid contained within a rotating prism whose cross section was a sector of a circle, came to the conclusion that when the angle of the sector was greater than two right angles a surface of discontinuity would form if the fluid were perfect, but that there would be no true surface of discontinuity in the case of a viscous fluid.

In 1868 Helmholtz (5) pointed out that whenever the velocity in the continuous potential flow exceeds a certain limit, the pressure becomes negative and the liquid tears asunder forming either a cavity or a surface of discontinuity. There is no doubt that a kind of cavitation actually exists in certain motions of real fluids, being assisted in the case of water by the air which is dissolved in it. The idea was developed by Lord Kelvin (6) in a remarkable paper "On the formation of coreless vortices by the motion of a solid in an inviscid incompressible fluid," in which he concludes that if the square of the velocity of a spherical solid exceeds $\frac{8}{5} P$, where P is the pressure in the undisturbed fluid at infinity, cavitation will commence at the back of the sphere and coreless vortices will be periodically formed and shed off behind the sphere during its motion through the fluid. This result is of interest in connection with the recent developments which will be described in §2; its importance has recently been emphasized by J. B. Henderson (7). D'Alembert's paradox is considered by some writers (8) to indicate that a surface of discontinuity must form when a solid body moves through a perfect fluid. Duhem (9) on the other hand regards it as implying the impossibility of a permanent régime and has shown that the paradox still holds when there are surfaces at which the velocity is discontinuous, provided the surfaces do not extend to infinity or, in the alternative case, provided the discontinuity vanishes at infinity at least as rapidly as the velocity of the fluid itself and in such a manner that a certain integral over a large surface inclosing the fluid, vanishes when this surface recedes to infinity. Villat (10) maintains, however, that a surface of discontinuity which extends to infinity, can exist when there is a permanent régime, but that the discontinuity of velocity does not satisfy the conditions laid down in Duhem's theorem, as is indicated by the mathematical analysis in a particular example. Consequently the possibility of a surface of discontinuity behind a moving body is not excluded by Duhem's argument. Moreover, M. Brillouin (11) has shown that if the pressure vanishes at infinity and there is a permanent régime, when a solid body moves uniformly through a perfect fluid there must be points at which the pressure is negative unless there is at least one surface of discontinuity which extends to infinity. This is a generalization of the result obtained by Lord Kelvin.

The mathematical theory of the motion of a perfect fluid in which there are vortex sheets or surfaces of discontinuity at which one portion of fluid glides past another, was first definitely applied to practical problems by Helmholtz (12). In the first instance the surface of discontinuity was introduced simply as a free surface of the stream of fluid flowing from a large reservoir into a narrow channel. Helmholtz concluded that the ultimate width of the stream would be half that of the channel, a result which is not very far from the truth (13). He was thus able to give a fairly satisfactory mathematical theory of jets, which accounted for the well-known instability of gaseous jets (14). In the case of a jet of fluid in air a finite discontinuity in velocity is inadmissible owing to viscosity, but it is conceivable that Helmholtz's theory may be arrived at in the limiting case when the viscosity tends to zero.

The theory of surfaces of discontinuity was afterwards extended to the case in which a solid moves through a fluid, and the mathematical analysis was developed by Kirchhoff (15), Rayleigh (16), and many other writers (17). Considerable progress has been made recently in this theory of discontinuous potential flow, by Levi-Civita (18), Cisotti (19), and Villat (20).

The theory has been used to determine the resistance met by a solid body moving through a perfect fluid, on the assumption that the wake behind the body is a region of constant (or hydrostatic) pressure bounded by a surface of discontinuity extending to infinity. A definite finite value is found for the resistance, and so the theory is not ruled out on account of D'Alembert's paradox. The theory agrees with experiment inasmuch as the resistance is found to be proportional to the square of the velocity of the body, but the calculated value for the resistance in the case of a plane lamina moving through air differs from the experimental value (21).

The theory of discontinuous motion has been attacked by Lord Kelvin (22), who claims that such a motion is inconsistent with his theorem of least energy; that a surface of discontinuity is unstable (23) and would also disappear on account of viscosity. Another serious objection is that the mass of "dead water" which is supposed to be carried along behind a body moving through a fluid, would have an infinite kinetic energy and this would imply that an infinite amount of kinetic energy is given to the fluid by the motion of the body. Since, however, the velocity of the body is supposed to be maintained by some agency, it has been thought that the type of motion in question might (conceivably) be approximated to asymptotically as time elapses, though it could not be established in a finite time (24).

The whole matter has been reviewed at some length by Lanchester (25) who points out that Lord Kelvin's minimum theorem involved the hypothesis of continuity, and so the first objection can be set aside. In connection with the other objections Lanchester states his views as follows:

(1) That whatever may be the value of the viscosity, the *initial* motion from rest obeys the Eulerian equations, i. e., the motion is continuous (26).

(2) That the discontinuous system may, in a viscous fluid, be regarded as arising by evolution from a motion initially obeying the mathematical equations of continuous motion.

(3) That in fluids possessing different values of kinematic viscosity the time taken for the evolution of the discontinuous system is greater when the kinematic viscosity is less, and vice versa.

(4) That the ultimate development of the discontinuous system of flow is more complete the less the value of the kinematic viscosity, and vice versa.

The possibility of the solution of the equations of motion of a viscous fluid becoming discontinuous when the viscosity approaches the value zero, may perhaps be illustrated by a consideration of the equation:

$$\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}=\nu\frac{\partial^2 u}{\partial x^2}.$$

This equation possesses a solution of the form

$$u=F(x+Ut),$$

if

$$U\frac{dF}{dx}+F\frac{dF}{dx}=\nu\frac{d^2F}{dx^2}$$

or

$$(F+U)^2\pm a^2=2\nu\frac{dF}{dx}$$

where a is a constant. The solution is thus either

$$u+U=a\tan\frac{(x+Ut-c)a}{2\nu}$$

or

$$\frac{a-u-U}{a+u+U}=e^{\frac{a}{\nu}(x+Ut-c)},$$

according as the + or − sign is taken. In the first case there is no definite value of u when ν tends to zero, while in the second case the limiting value of u is either $a-U$ or $-a-U$ according as $x+Ut$ is less or greater than c. The limiting form of the solution is thus discontinuous.

It is clear from this example that the question of the limiting form of the motion of a viscous fluid when the viscosity tends to zero requires very careful investigation. So far very little has been done on these lines, but an approximate mathematical theory of the motion of a fluid whose viscosity is very small has been proposed by Prandtl (**27**) and developed by some of his pupils (**28**). The chief characteristic of the theory is the assumption that the motion differs very little from a continuous potential flow outside a "thin layer of transition" and that within this layer there is a rapid fall of velocity; for the motion in this layer the equations of motion of a viscous fluid are used with a few simplifications.

The conclusions to which Prandtl comes are very similar to those in Lanchester's treatise. In the case of the flow of fluid round a plate, when the flow is directed at right angles to the plate at an infinite distance from it, the motion differs very little from the continuous potential flow at the very beginning of the motion, being changed very little by the thin layer of transition covering the edges. Soon, however, the fluid separates from the plate and in consequence of the friction at the wall a stream of fluid containing vortices issues from the layer of transition. The type of flow now changes behind the place of separation and a kind of vortex sheet or surface of discontinuity appears to form, only to be broken up on account of its instability into separate vortices. These conclusions have been verified by a series of experiments. A photographic reproduction of the pictures representing the flow is given in Prandtl's paper.

A complete mathematical study of the motion of a viscous fluid as its velocity increases is very desirable. The motion of a sphere in a viscous fluid when the velocity of the sphere is small has been studied very thoroughly by C. W. Oseen (**29**); he has made some allowance for the "inertia terms," i. e., the terms in the equations of motion which involve products of the component velocities and their derivatives, and he finds that when $\rho aU/\mu$ is small —ρ being the density, μ the coefficient of viscosity of the fluid, a the radius of the sphere, and U its velocity —the resistance is given to a second approximation by the formula:

$$R=6\pi a\mu U\left[1+\tfrac{3}{8}\frac{\rho aU}{\mu}\right].$$

A similar result has been obtained recently by R. W. Burgess in a paper which has just been presented to the American Journal of Mathematics. Burgess has, moreover, removed a defect in Oseen's theory and has obtained the modified stream-line function by a simple process.

The first approximation for R, of course, agrees with Stokes's well-known formula. An approximate formula for the resistance to the uniform motion of a right circular cylinder has been obtained by Lamb (**30**), the method of derivation being analogous to that used by Oseen.

In these investigations it is assumed that the motion is steady. There is, of course, vortex motion which is appreciable only in the wake, but there are no isolated vortices or cavities and no surfaces of discontinuity. If a steady motion exists, the origin of these other types of motion must be attributed to chance disturbances and a possible instability of the steady state. Since, however, in actual experiments a finite velocity of a moving solid is attained gradually, the turbulent or discontinuous motion may begin when the velocity exceeds a certain limit, depending on the viscosity, as in the theory of Osborne Reynolds (**31**). In this theory it is recognized that a possible criterion of stability of a given state of motion can depend only on the ratio $\frac{\rho aU}{\mu}$, where a is a characteristic length and U a characteristic velocity associated with the motion. Osborne Reynolds was led to the idea that turbulence sets in when this quantity exceeds a certain limit. This theory has been discussed with conflicting conclusions by Lord Kelvin (**32**), Lord Rayleigh (**33**), H. A. Lorentz (**34**), W. McFadden Orr (**35**), F. R. Sharpe (**36**), V. W. Ekman (**37**), C. W. Oseen (**38**), A. Sommerfeld (**39**), G. Hamel (**40**), R. von Mises (**41**), and other writers. The question must still be regarded as unsettled.

On account of instability it is difficult to understand how a surface of discontinuity could be approximated to during the course of the motion of a viscous fluid; nevertheless the results which are obtained by means of the theory apparently agree qualitatively with experiments, so that it would be unwise to reject the theory simply on account of this difficulty.

One serious objection which can be urged against the theory on experimental grounds, is that the theory does not account for the variation of pressure observed over the back of a square plate moving through air.

The distribution of pressure over both faces of a plane lamina moving with constant velocity through air has been determined experimentally by several observers (**42**). In some cases a whirling table was used, but the results obtained in this way are not satisfactory. The best observations have been made by carrying the lamina in a moving vehicle as in some of Langley's experiments. Armand de Gramont, Duc de Guiche, has recently adopted this method in an elaborate series of experiments carried out in a motor car and has made a number of beautiful diagrams which show very clearly that the pressure on the back of a thin square lamina is less than the atmospheric pressure over an area bounded by the leading edge and a curve which recedes toward the rear edge of the plate as the angle of inclination increases from 0° up to a critical

angle of about 20°. When this angle is exceeded the pressure on the back of the plate is everywhere less than the atmospheric.

The critical angle differs from that found by Eiffel in his experiments with a stationary plane in a current of air and this indicates that results obtained by one method of experiment can not be applied with full rigor to cases which would correspond to the other method of experiment.

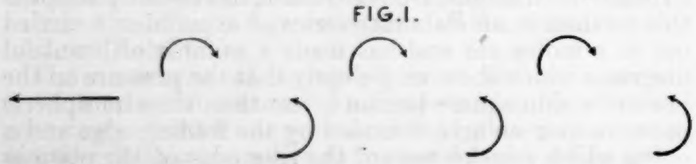
Unless the presence of the motor car alters the flow of air the exact cause of the difference between the two cases is not easily detected. In the mathematical theory it has generally been assumed that the flow of fluid around a stationary obstacle can be deduced at once from the corresponding flow, in which the fluid is at rest at infinity and the body moves through it, by simply impressing on the fluid and the body a velocity which will annul the velocity of the body. This may, however, only be true when the motion is steady. The question has been raised again and discussed in a recent paper by J. B. Henderson (**43**) who refers to some experiments made by Dubuat in 1786. This experimenter measured the force required to tow a plate in still water, and also the force required to hold the same plate stationary in a stream, the relative motion of plate and water being the same in the two cases. He found the ratio between the two forces to be 1.3:1.

A possible explanation of the difference, assuming it to be real, is that the eddy phenomena are not the same in both cases. Eddies arise from instability in the steady motion, and to prove the equivalence it would have to be proved, not only that the inception of instability, but also that the resulting motion following on instability depend solely on the relative motion (**43**).

It is very probable that conditions in which the motion of the fluid is not really steady play an important part in experimental work and this brings us to the consideration of motions which are permanent because they are periodic.

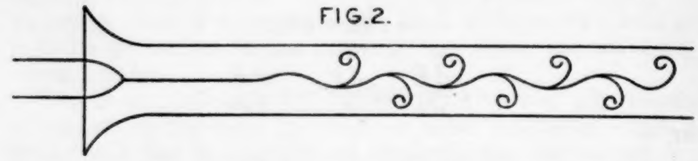
2. In 1908 H. Bénard (**44**) discovered that when the surface of a liquid is parted by a thin vertical prism which is moved with uniform velocity parallel to its plane of symmetry, two parallel sets of gyration centers form behind the prism. The vortices belonging to a row are at equal distances apart and have the same sense of rotation which is opposite, however, to that of the vortices in the other row. A central dissymmetrical space was detected at the back of the prism and was identified with the vibration zone where the alternate vortices are formed. At two instants separated by half a period, the appearance of the zone is exactly symmetrical with regard to the plane of symmetry of the obstacle. At first the vortices have the same velocity as the moving prism, but quickly slacken, at the same time diverging to the right and left. They quickly attain their transversal limit, longitudinal equidistance, and limiting speed, which are preserved if the vortices are not too much deadened. When old they are more and more sensible to accidental fluctuations, while the equidistance, in particular, is less and less well defined. The arrangement of vortices is indicated in the following figure (fig. 1).

FIG. 1.



An alternate periodic arrangement of vortices of this type has been observed many times. In the following diagram (fig. 2), taken from a paper by Osborne Reynolds (**45**), a series of spiral-shaped eddies is shown which bears some resemblance to the above arrangement. The diagram indicates the way in which a thin stream of liquid becomes unstable when moving through another liquid.

FIG. 2.



A somewhat similar arrangement of vortices is produced by the blades of a screw propeller (**46**) and a vibration of the vortex field has been noticed in some experiments on the flow of water round a model balloon (**47**), while Borne (**48**) has recently verified the fact that vortex filaments are formed alternately in the flow of air round different obstacles and has obtained some photographic records of the phenomena in question.

Experiments analogous to those of Bénard have also been made by Rubach (**49**), Kármán (**49**) and others with similar results. In the case of a circular cylinder moving through a liquid Rubach (**50**) found that two vortices with opposite directions of rotation are soon formed behind the cylinder and their strength continually increases, new rotating fluid being derived from the "layer of separation" which first forms behind the cylinder. The pair of vortices recedes from the cylinder with a velocity which is small compared with the progressive velocity of the cylinder and its pair of vortices relative to the stationary fluid. This state of affairs, however, is unstable; a periodic motion soon sets in with a continual formation of new vortices from opposite sides of the cylinder.

A mathematical theory of the two rows of vortices considered above has been given by Kármán (**49**), who finds that under certain circumstances such a system is stable.

In the case of a perfect incompressible fluid, the motion of a system of isolated rectilinear vortex filaments whose axes are all parallel, may be studied by a well-known method (**51**). Since each vortex moves with the fluid, the velocity of a vortex, A_p, can be calculated from the stream-line function due to the remaining vortices. Writing $z = x+iy$, $w = x-iy$, the equations of motion of the vortex A_p are contained in the single equation

$$\frac{dz_p}{dt} = \frac{i}{2\pi}\sum_q{}' \frac{k_q}{w_p - w_q},$$

where k_q is the strength of the vortex A_q and the prime denotes that in the summation q does not take the value p.

To study the small vibrations of the system, we write $z_p+\zeta_p$ instead of z_p, $w_p+\xi_p$ instead of w_p and neglect terms of order higher than the first in the small quantities ζ_p, ξ_p. We thus obtain

$$\frac{d\zeta_p}{dt} = -\frac{i}{2\pi}\sum_q{}' k_q \frac{\xi_p - \xi_q}{(w_p - w_q)^2}.$$

So far the work is quite general. Now let us assume that the vortices in the first row are all of strength k and that their undisturbed positions are given by

$$z_q = ql, \quad q = 0, \pm 1, \pm 2, \cdots$$

Let us assume, moreover, that the vortices of the second row are each of strength $-k$, and that their undisturbed positions are given by

$$z_r = (r+\tfrac{1}{2})l + ih,\ r=0,\ \pm 1, \pm 2, \ldots$$

For simplicity each row of vortices is supposed to extend to infinity both ways.

Using the inferiors p, q, for vortices in the first row, and r, s, for vortices in the second row, we obtain the equations

$$\frac{d\zeta_p}{dt} = -\frac{ik}{2\pi}\sum_{q=-\infty}^{\infty}{}' \frac{\xi_p-\xi_q}{(p-q)^2l^2} + \frac{ik}{2\pi}\sum_{r=-\infty}^{\infty} \frac{\xi_p-\xi_r}{[(p-r-\frac{1}{2})l-ih]^2};$$

$$\frac{d\zeta_s}{dt} = +\frac{ik}{2\pi}\sum_{r=-\infty}^{\infty}{}' \frac{\xi_s-\xi_r}{(s-r)^2l^2} - \frac{ik}{2\pi}\sum_{q=-\infty}^{\infty} \frac{\xi_s-\xi_q}{[(s-q+\frac{1}{2})l+ih]^2}.$$

Now consider the disturbance in which ζ_p, ζ_s, ξ_p, ξ_s, are the unambiguous parts of the expressions $\zeta_0 e^{\pm ip\phi}$, $\zeta_1 e^{\pm i(s+\frac{1}{2})\phi}$, $\xi_0 e^{\pm ip\phi}$, $\xi_1 e^{\pm i(s+\frac{1}{2})\phi}$, respectively, ϕ being a real quantity independent of p and s and unambiguous, while ζ_0, ζ_1, ξ_0, ξ_1 are real or complex quantities which may involve the ambiguity $\pm$. Let us assume, moreover, that ξ_0, ζ_0, ξ_1 and ζ_1 depend on t through a factor type $e\theta_t$. We then have

$$\zeta_0\theta + \lambda\xi_0 + i\mu\xi_1 = 0, \quad \zeta_1\theta - \lambda\xi_1 - i\nu\xi_0 = 0,$$

where

$$\lambda = \frac{ik}{\pi}\sum_{n=l}^{\infty}\frac{1-\cos n\phi}{n^2l^2} - \frac{ik}{2\pi}\sum_{m=-\infty}^{\infty}\frac{1}{[(m-\frac{1}{2})l-ih]^2},$$

$$\mu = \frac{k}{2\pi}\sum_{m=-\infty}^{\infty}\frac{e^{\pm(m+\frac{1}{2})i\phi}}{[(m+\frac{1}{2})l+ih]^2},$$

$$\nu = \frac{k}{2\pi}\sum_{m=-\infty}^{\infty}\frac{e^{\pm(m+\frac{1}{2})i\phi}}{[(m+\frac{1}{2})l+ih]^2}.$$

In a similar way we find that

$$\xi_0\theta - \lambda\zeta_0 + i\nu\xi_1 = 0, \quad \xi_1\theta + \lambda\zeta_1 + i\mu\zeta_0 = 0.$$

Eliminating ξ_0, ξ_1, ζ_0, ζ_1, we obtain the equation

$$(\theta^2+\lambda^2+\mu^2)(\theta^2+\lambda^2+\nu^2) - \lambda^2(\mu-\nu)^2 = 0$$

which is satisfied by

$$\theta = \pm\tfrac{i}{2}(\mu-\nu) \pm i\sqrt{\lambda^2+\tfrac{1}{4}(\mu+\nu)^2}.$$

For stability it is necessary that θ should be a purely imaginary quantity. Now $\mu-\nu$ and $\mu+\nu$ are real, consequently for stability $\lambda^2+\frac{1}{4}(\mu+\nu)^2$ must be positive for all real values of the quantity ϕ, which specifies the relations between the phases of the different vortices. Now when $\phi = \pi$, $\mu+\nu = 0$, hence for stability λ must also vanish when $\phi = \pi$, otherwise λ^2 would be negative and there would be two values of θ with a positive real part. The equation $\lambda^2 = 0$ reduces, when $\phi = \pi$, to $\cosh^2\frac{h\pi}{l} = 2$, or

$$\frac{h}{l} = 0.283 \ldots \qquad (1)$$

For other ratios of h to l the system of vortices is unstable. A complete proof that the system is stable for all displacements when h and l are connected by the relation (1) has not been given, and in spite of Kármán's assertion, there is some doubt about the truth of the theorem, judging from the report of a paper presented to the Royal Society of Edinburgh on March 1, 1915, by H. Levy. It is easy to see, however, that $\lambda^2+\frac{1}{4}(\mu+\nu)^2$ is positive when $\phi = 0$.

The velocity U with which the whole system of vortices moves is given by the formula

$$U = \frac{k}{\pi}\sum_{m=0}^{\infty}\frac{h}{(m+\frac{1}{2})^2l^2+h^2} = \frac{k}{2l}\tanh\frac{\pi h}{l} = \frac{k}{l\sqrt{8}}$$

Kármán has used the two rows of vortices to obtain a theory of resistance in which the resistance encountered by a body moving with uniform velocity, V, in a perfect fluid is expressed in terms of V, h, l, and the width of the body in a direction perpendicular to the direction of motion. The quantity l may be obtained experimentally from observations of the periodic system of vortices in the wake behind the body.

In connection with the flow produced by a moving right circular cylinder, L. Föppl (50) has investigated whether there are any places behind a cylinder in uniform motion, where two equal vortices with opposite senses of rotation can be placed so as to be at rest relative to the cylinder. By considering the images of the vortices in the cylinder, he finds that the vortices must lie in symmetrical positions on the curves $\pm 2y = r - \frac{1}{r}$, where r is the distance of a point from the axis of the cylinder, the radius of the cylinder being unity. This result has been tested by an examination of Rubach's photographs and agrees very well with the measurements. The strength of the vortices is greater the farther they are from the axis of the cylinder.

3. Let us now see what relation some of the preceding results and theories may have to atmospheric problems.

In his memoir "Über atmosphärische Bewegungen" (52) Helmholtz has made some remarks on the origin of depressions and anticyclones and has considered the possibility of surfaces of discontinuity in the atmosphere, these being surfaces which separate masses of air with different velocities and different temperatures or densities. Such surfaces are sooner or later broken up, eddies are formed, and the masses of air at different temperatures intermingle. Helmholtz thus regards instability as a more powerful cause than friction in establishing a transition stratum within which the change of density takes place gradually. The effect of viscosity in smoothing out discontinuities may be studied by considering some of the well-known problems in the theory of the conduction of heat, wherein a discontinuity in the initial conditions instantly disappears after a time. Helmholtz remarks (53) that—

> As in the neighborhood of the Equator the air of the earth's surface is warmed and rises, so in the neighborhood of the poles it is cooled and sinks. The cold layers will endeavor to flow separately to the earth and form east winds; above them the vacant place must be filled and the warm air blows there as a west wind or cyclone. It would be possible for there to be equilibrium if the lower cold layers did not require a more rapid motion of rotation owing to friction. The spreading out of the polar east winds, if it is indeed recognizable in its principal features, takes place very irregularly, since the cold pole does not coincide with the rotation-pole of the earth and low hills have considerable influence. Through such irregularities it happens that the anticyclonic movement of the lower layers and the gradually increasing cyclone of the upper layers, which is to be expected at the pole, resolve themselves into a large number of irregularly moving cyclones and anticyclones with a preponderance of the former.

This idea has been recently taken up and developed by F. M. Exner (54), who has combined it with some results

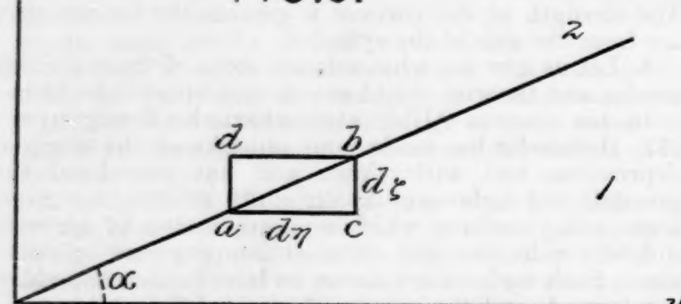
obtained by M. Margules (55). The fundamental hypotheses may be briefly stated as follows:

Let us suppose, with Helmholtz, that in the neighborhood of the pole the cooled air sinks and endeavors to spread out toward the south beneath the overlying warmer layers, like a heavy fluid beneath a lighter one. By the deviating force of the earth's rotation the flow of cold air toward the south should be directed toward the west, the cold air should therefore enter the high latitudes as east winds; south of this the warm west wind should prevail. According to the calculations of Helmholtz and Margules, the cold layer can lie in a state of equilibrium like a wedge below the warm air. On account of the friction at the earth's surface which the lowest layers experience, the cold east wind and the warm west wind are retarded; the surface of separation is consequently not stable but bends toward the horizon. Cold air flows southward, while warm air flows northward.

This is an overturning of the layers in the sense of Margules, whereby kinetic energy is set free by the work of gravity. Exner has made some calculations to ascertain whether, under plausible assumptions as to the magnitude of the friction, this is sufficient to account for the great air movements, and he finds that this is the case. He then says:

Since the friction on a parallel of latitude is very different for different lengths, there is a very different production of kinetic energy in different places. This signifies the generation of depressions at certain parts of a parallel of latitude, which are characterized by particularly great hindrances to the east-west air motion. The growth of depressions may consequently be connected with certain spots on the earth's surface. Among these the continent of Greenland plays a particularly important part, for the cold east winds are dammed at its east front and thrown toward the south. On account of the lack of observations in high latitudes this conclusion has unfortunately not been sufficiently confirmed.

FIG. 3.



An examination of the weather maps of the Northern Hemisphere (56) will show that this theory of Helmholtz and Exner does account for the general features of the pressure distribution, as there is frequently a circle of lows at about the same latitude as Greenland, and this ring of lows is surrounded by a belt of highs. The arrangement of these lows and highs bears some resemblance to Bénard's two rows of vortices, but unfortunately the lows are more numerous than the highs, so that a high is not always equidistant from two consecutive lows as in Bénard's arrangement.

Very little has been done in the theory of the stability of a large number of isolated vortices, that might conceivably have an application to atmospheric problems. Perhaps the arrangement considered by Lord Kelvin in his paper "On the stability and small oscillations of a perfect liquid full of nearly straight coreless vortices" (57) might with advantage be transferred to the surface of a sphere and studied more fully. More progress has been made in the theory by using the idea of a surface of discontinuity, although, as Exner remarks, there is no direct evidence that a sharp discontinuity in temperature occurs. Nevertheless the results which are obtained by using the idea may be expected to closely resemble the actual conditions.

When the surface of discontinuity is stationary, its inclination may be deduced from a formula given by Margules (58).

Using the equations for stationary rectilinear motion in the form

$$\frac{1}{\rho_1}\frac{\partial p_1}{\partial y}=2\omega\sin\phi.u_1, \qquad \frac{1}{\rho_1}\frac{\partial p_1}{\partial z}=-g,$$

$$\frac{1}{\rho_2}\frac{\partial p_2}{\partial y}=2\omega\sin\phi.u_2, \qquad \frac{1}{\rho_2}\frac{\partial p_2}{\partial z}=-g,$$

where u is the velocity parallel to the axis of X, p the pressure, ρ the density of the air, ω the angular velocity of the Earth, and ϕ the latitude, he writes

$$p_c-p_a=\frac{\partial p_1}{\partial y}.d\eta=2\omega\rho_1 u_1\sin\phi.d\eta.$$

$$p_b-p_c=\frac{\partial p_1}{\partial z}.d\zeta=-g\rho_1.d\zeta.$$

$$p_b-p_d=\frac{\partial p_2}{\partial y}.d\eta=2\omega\rho_2 u_2\sin\phi.d\eta.$$

$$p_d-p_a=\frac{\partial p_2}{\partial z}.d\zeta=-g\rho_2.d\zeta.$$

therefore

$$2\omega\rho_1 u_1\sin\phi.d\eta-g\rho_1 d\zeta=p_b-p_a=2\omega\rho_2 u_2\sin\phi.d\eta-g\rho_2.d\zeta,$$

and so

$$\tan\alpha=\frac{d\zeta}{d\eta}=\frac{2\omega\sin\phi}{g}\cdot\frac{\rho_1 u_1-\rho_2 u_2}{\rho_1-\rho_2}.$$

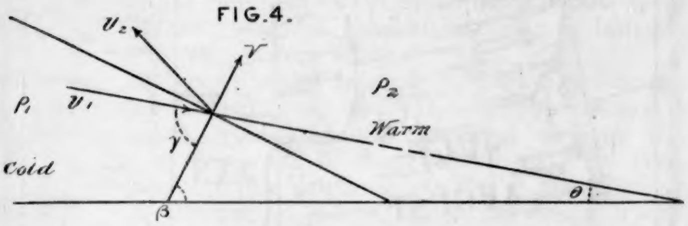
Margules also obtains a more exact formula by taking into account the curvature of the Earth. Sandström (59) has shown further that it is possible to derive the variation in intensity of a vortex sheet from the inclination of the surface of discontinuity as well as from the temperature and distribution of humidity in the neighborhood of the surface. He also gives a criterion depending on the relative velocity (60). Some evidence of the existence of a condition in the atmosphere closely resembling a surface of discontinuity has been obtained by W. Schmidt in his observations of air-waves in valleys (61). He finds that the amplitudes of the waves increase continuously as the warm föhn current aloft sinks to the surface, until they suddenly end when the föhn breaks through. He considers that the air-waves are formed at the upper surface of the cold valley wind over which blows the warm current of the föhn. The appearance of the air-waves is frequently associated with an advancing depression, and may thus be regarded as a weather prognostic.

The motion of surfaces of discontinuity in the atmosphere may perhaps be studied with the aid of some well-known theorems relating to the propagation of waves of discontinuity (62). One of these theorems may be deduced at once from the equation of continuity. It states that if V is the velocity of the surface of discontinuity in a direction at right angles to itself, v_1 and v_2 the component velocities of the air on the two sides of the surface in a direction at right angles to the surface, ρ_1 and ρ_2 the densities of the two contiguous masses of air, then

$$\rho_1(V-v_1)=\rho_2(V-v_2)\quad.$$

Let us apply this equation to the case of a line squall on the supposition that the inclination of the surface of discontinuity to the horizon is as shown in figure 4.

FIG.4.



Let U_1, U_2, be the velocities of the air on the two sides of the surface of discontinuity.

Since the rate of advance of the line of the squall is a little greater than the surface velocity of the colder air (**63**) we have

$$V \cos\beta > U_1 \cos\theta$$

Now $v_1 = U_1 \cos \gamma$, and $\cos\theta = \cos\beta\cos\gamma + \sin\beta\sin\gamma$, therefore $\cos \theta > \cos\gamma\cos\beta$, and so $v_1 < U_1\cos\theta\sec\beta < V$. It follows then that V is also greater than v_2. This means that warm air flows across the surface of discontinuity and mixes with the cold air, a result which may perhaps be regarded as an illustration of the principle that heat always flows freely from the warmer mass to the cold and not vice versa. The supposition made with regard to the inclination of the surface of discontinuity and its velocity, is thus consistent with the above equation of continuity.

The flow of fluid past a spherical obstacle has an interesting application to the atmospheric problem of the flow of air past a hemispherical mountain, as has been pointed out by W. Schmidt (**64**). The influence of the compressibility of the air has been considered by Y. Okada (**65**) and has been found to be negligible, provided the velocity of the air is small compared with the velocity of sound. When the surface of the mountain is treated as a half cylinder, the investigations in the paper of L. Föppl (**50**) become of interest. By reducing the cylinder to rest, we see that it is possible for a stationary vortex to form behind the mountain, a result which agrees with observations. L. Föppl's investigation of the stability of the two vortices behind a circular cylinder is thus of interest for the atmospheric problem. It must be remembered that in this case the two vortices must always be images of one another in the plane of symmetry, i. e., the plane which divides the cylinder into two halves; the displacements of the two vortices are consequently symmetrical with regard to this plane and the arrangement is stable, whereas for asymmetrical displacements the arrangement is unstable.

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(3) **Helmholtz.** Monatsbericht, Berlin, 1868. Wissenschaftliche Abhandlungen, Berlin, 1882. **1**:146–157. *See also* **Abbe, C.** The Mechanics of the earth's atmosphere, [II], Washington, 1891, p. 58.

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(5) **Helmholtz,** loc. cit. under (3).

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(13) For some recent remarks on this problem see
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III. THE DISTRIBUTION OF THE RAINFALL IN THE WESTERN UNITED STATES.

By B. C. Wallis, B. Sc. (Economics), F. R. G. S., F. S. S.

[Dated: North Finchley, England, Feb. 24, 1915.]

In this Review for January, 1915, the writer mapped in some detail and discussed the distribution of rainfall intensity in the eastern United States; the present paper is a similar discussion of the rainfall intensity in the western portion of the Republic.

The accompanying 12 monthly maps of equipluves (figs. 31–42) present a notable regularity almost throughout the year, a very wet area gradually fades off into a very dry district. The exceptional month is October, when the raininess is uniformly below the average, and the elevated lands are wetter than the lowlands. The second general feature is the absence of very marked raininess or dryness on the mountains at any time of the year. This fact is well shown by the graphs for the mountain divisions (fig. —). Consequently, in a broad way, the West contains three regions with three types of rainfall: (1) The Far West, including the coast lands, with great rainfall intensity throughout the period November to March, i. e., *winter rains;* (2) the Mountains, never very wet, never very dry; (3) the Eastern Slopes, with great rainfall intensity in the north from April to June, and in the south from July to September, i. e., *summer rains.*

In January the equipluves run north and south and raininess decreases steadily eastwards. This month marks the climax of the influences which cause rain and which are due, in the main, to the winds from the Pacific Ocean.

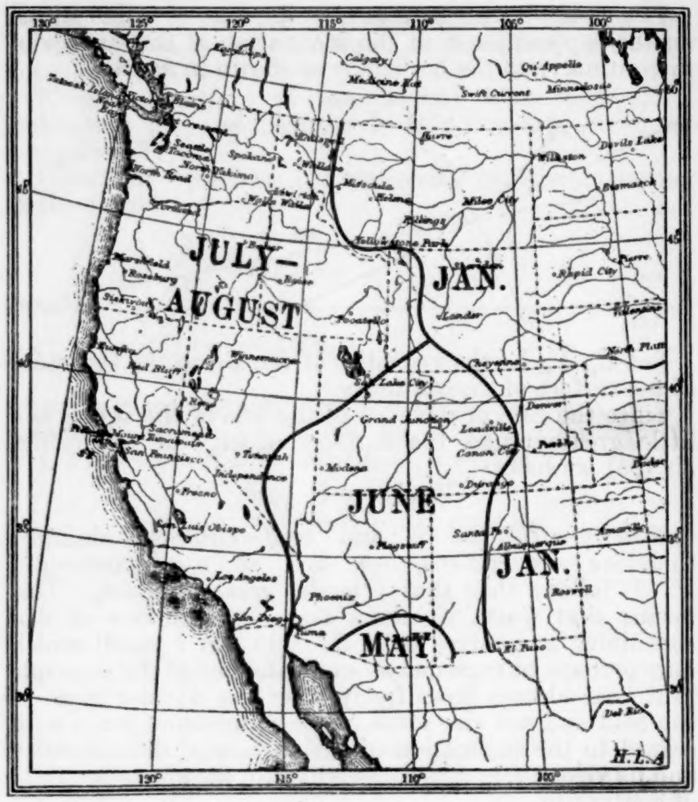

Fig. 24.—Map showing the driest months in the western United States.

In February the rainfall influences begin to weaken along the northwest coast and raininess increases on the eastern slopes.

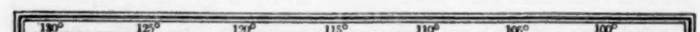

Fig. 25.—Map showing the wettest months in the western United States.

In March the northeast increases in wetness and the western influences weaken generally. By the month of April the influence of the Pacific winds has ceased to produce a marked intensity of rain and continental influences—due, in the main, to the "swing of the sun"—tend to produce raininess in the areas most remote from the sea; the area of great rainfall intensity is latitude 40°-45° N. on the eastern slopes.

In May the continental influences exert a maximum effect in this central area, and the southwest corner is relatively very dry. The June areas of wetness and dryness lie to the north of those which occur in May. In July the extreme southern section of the Mexican boundary of the United States, which lies within 3 or 4 degrees of the Tropic of Capricorn, begins to experience the northward-moving area of heavy rainfall always accompanying the "vertical" sun. Dryness prevails

FIG. 26.—Rainfall regions of the western United States.

over the western coast lands. In August, July conditions are continued and develop a more definite dryness in the north. In July and August the Pacific coast lands are marked by an exceptional dryness (below 10 per cent), being the minimum intensity of rainfall occurring anywhere in the United States.

In September the southern maximum and the western minimum persist, but in a less marked degree. October is a dry month in the United States, and it is slightly drier in the West than farther east. In November and December the oceanic influences begin to work toward their January maximum; they increase in power as the winter comes on and as they gradually reach farther southward.

Figures 24, 25, and 26 are based upon the monthly maps (figs. 31-42).

Roughly a line from El Paso to Missoula divides the United States into two parts having dry winters and dry summers, respectively.

On the other hand, meridian 115° W. divides the country into two parts which have wet winters and wet summers, respectively (fig. 25). Both these statements ignore the small coastal area of New England where the rainfall conditions tend to be unique.[1] Consequently, the western United States may be divided (fig. 26) into three rainfall areas: (*A*) the west coast with wet winters

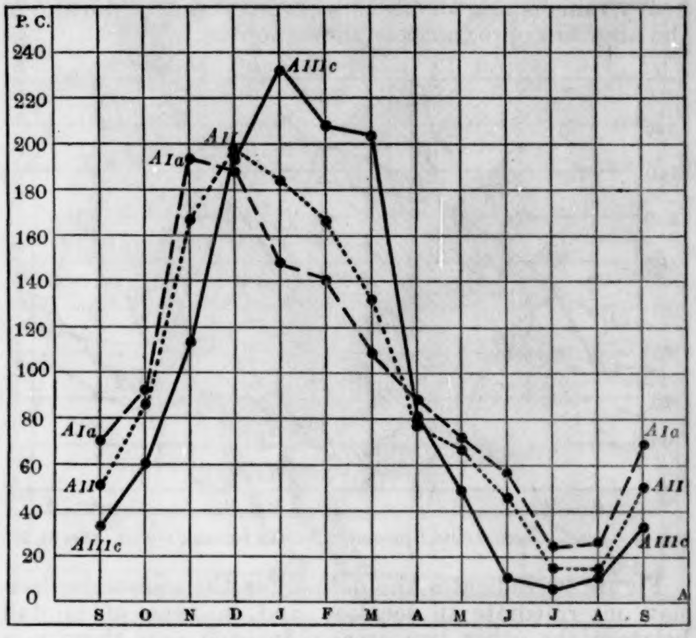

FIG. 27.—Annual march of rainfall intensity in rainfall regions *AIa*, *AII*, and *AIIIc*. (See fig. 26.)

and dry summers and a great range of rainfall intensity; (*B*) the eastern slopes with seasons the reverse of these, and also a great range of intensity; and (*C*) the mountains with indefinite rainfall seasons accompanied by a slight range of intensity, although the cold season tends to be rainier than the warmer half year.

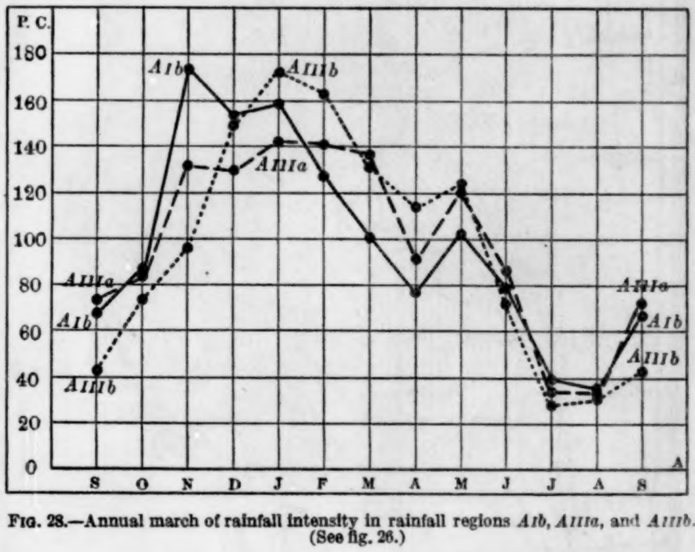

FIG. 28.—Annual march of rainfall intensity in rainfall regions *AIb*, *AIIIa*, and *AIIIb*. (See fig. 26.)

In the west coast divisions (fig. 27) the oceanic influences found on the north gradually increase in intensity southward. On the other hand, the oceanic influences decrease in intensity with distance from the coast (fig.

[1] See this REVIEW, January, 1915, 43: 16, 17, figs. 8 and 10.

28). The three areas, for which generalized graphs are shown, agree in having increased raininess which prevails in May in comparison with April. This latter fact is of interest in connection with the raininess of the interior of the continent in that month.

Figure 30 refers to the eastern slopes and shows how the maximum effect occurs in the center in May, in the north in June, and in the south in July. The period of heavy rains is also shown to be limited in each portion of the area to approximately three months.

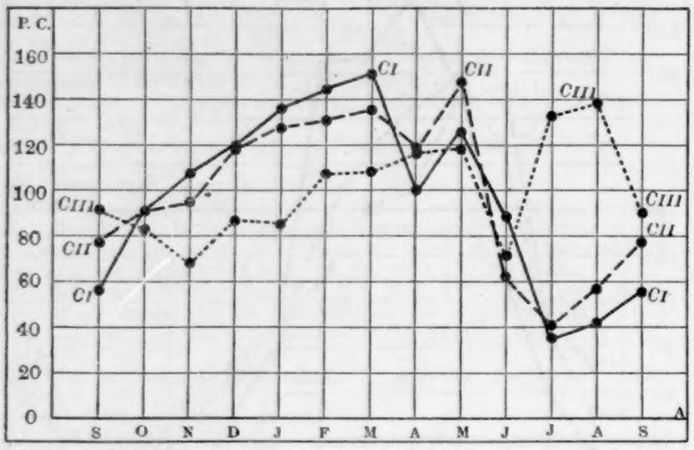

FIG. 29.—Annual march of rainfall intensity in rainfall regions *CI*—*CIII*. (See fig. 26.)

Figure 29 indicates the details for the mountain division intermediate in location and in type of rainfall between the other two areas. In each case there is a double maximum. It is interesting to note that in general the equinoxes are dates when the rainfall intensity tends to approach its average and when the periods of wetness and dryness, respectively, tend to terminate.

The location of these several rainfall regions are indicated in figure 26. In conjunction with the corresponding chart [2] of the rainfall regions of the eastern United States (fig. 8) figure 26 indicates that the rainfall of the United States as a whole is determined by (1) continental influences which are exerted over a broad triangle of country, with the vertex to the south and with the edge of the Rocky Mountains as the easte n limb of the triangle; (2) oceanic influences exerted upon the coastal

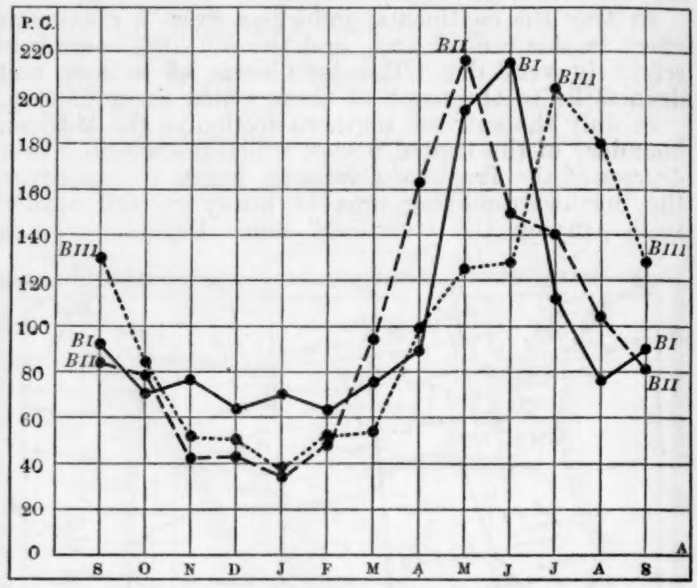

FIG. 30.—Annual march of rainfall intensity in rainfall regions *BI*—*BIII*. (See fig. 26.)

lowlands, (*a*) on the west from the Pacific and (*b*) on the east from the Atlantic; (3) intermediate regions (*a*) the Rockies in the west and (*b*) the western Appalachians on the east; and (4) direct solar influences which are manifest with some elements of variety along the southern boundary as far west as Yuma, Ariz.

[2] *See* this REVIEW, January, 1915, **43**: 16, 17, figs. 8 and 10.

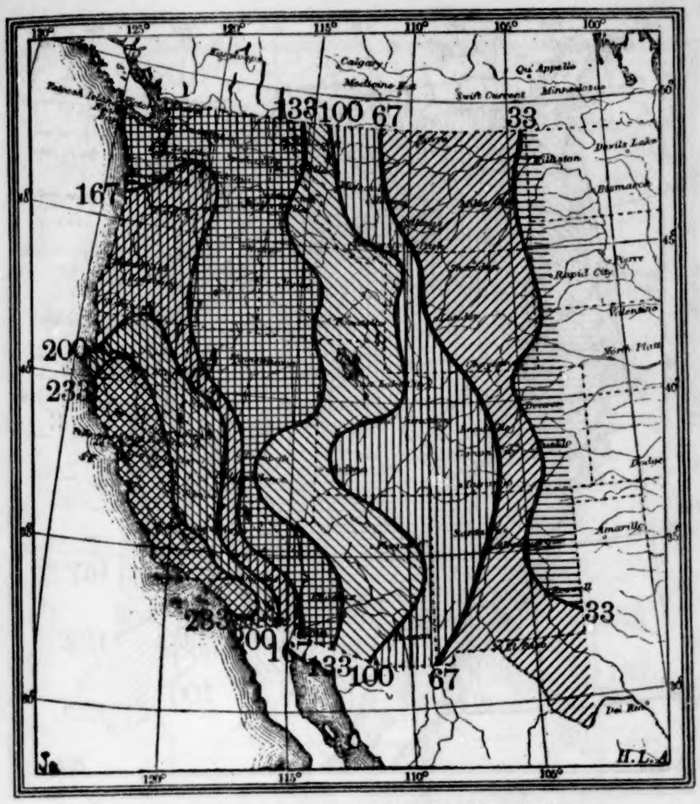

FIG. 31.—Equipluves for the western United States for January.

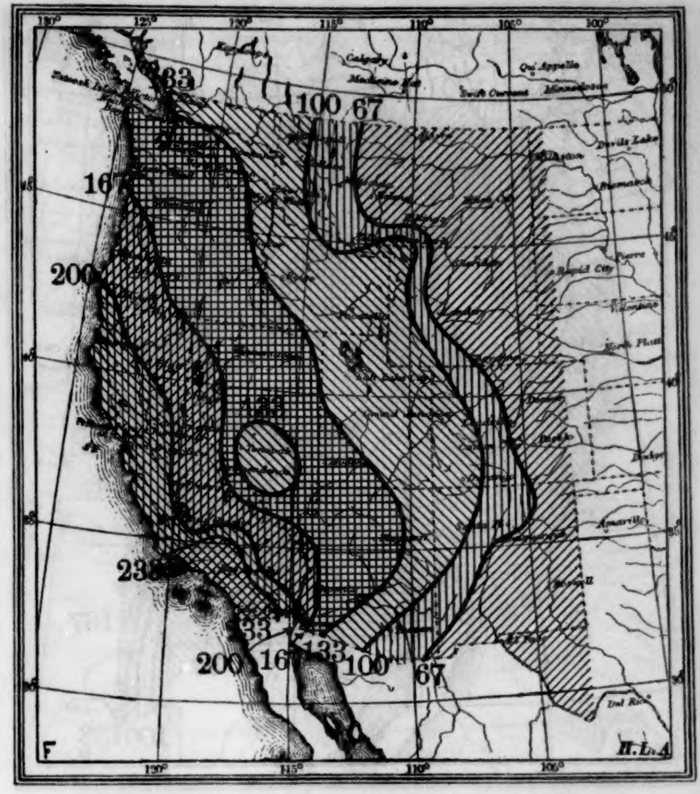

FIG. 32.—Equipluves for the western United States for February.

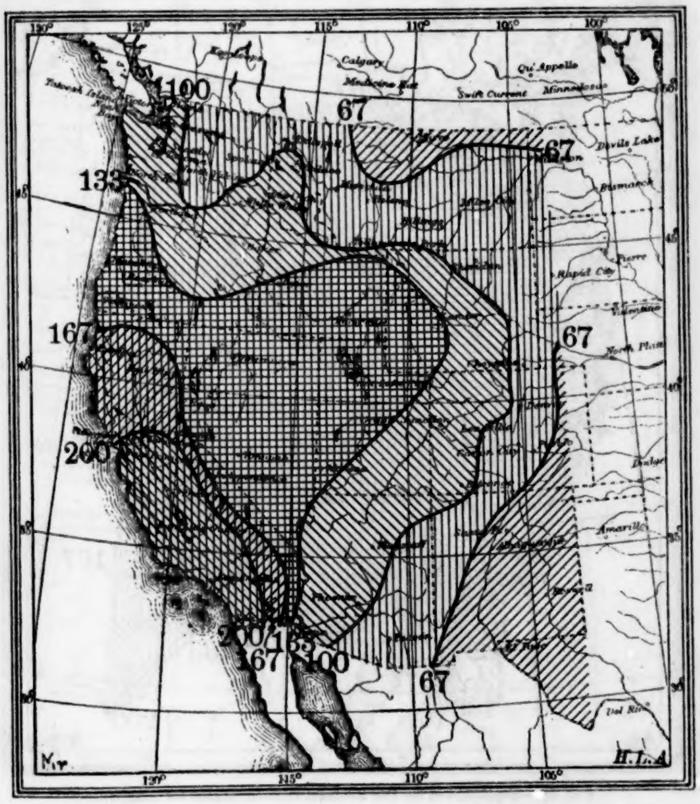

FIG. 33.—Equipluves for the western United States for March.

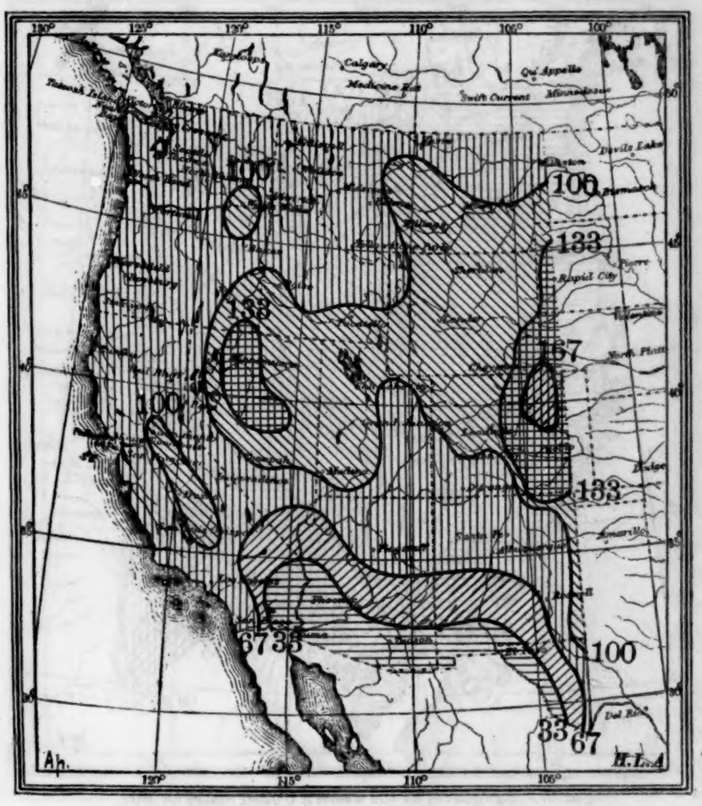

FIG. 34.—Equipluves for the western United States for April.

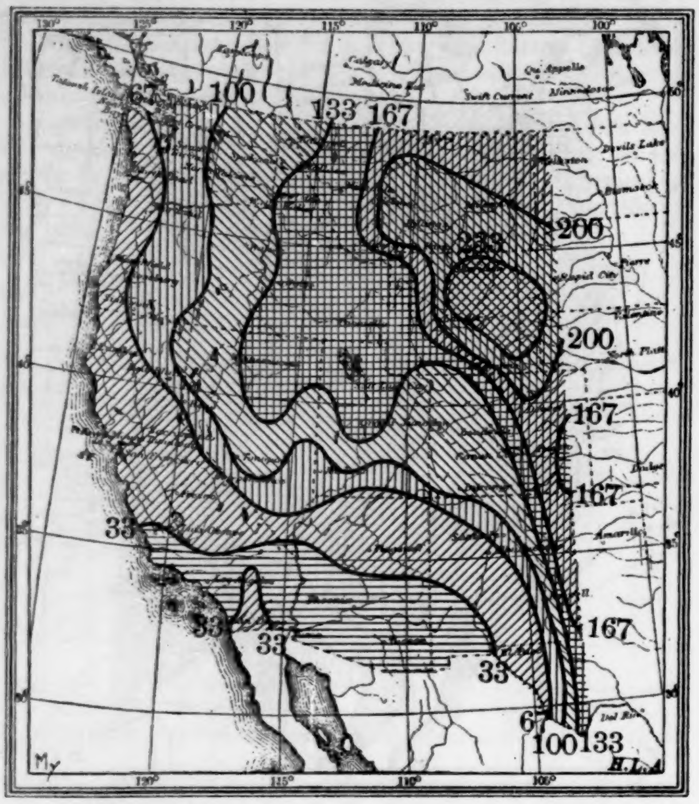

FIG. 35.—Equipluves for the western United States for May.

FIG. 36.—Equipluves for the western United States for June.

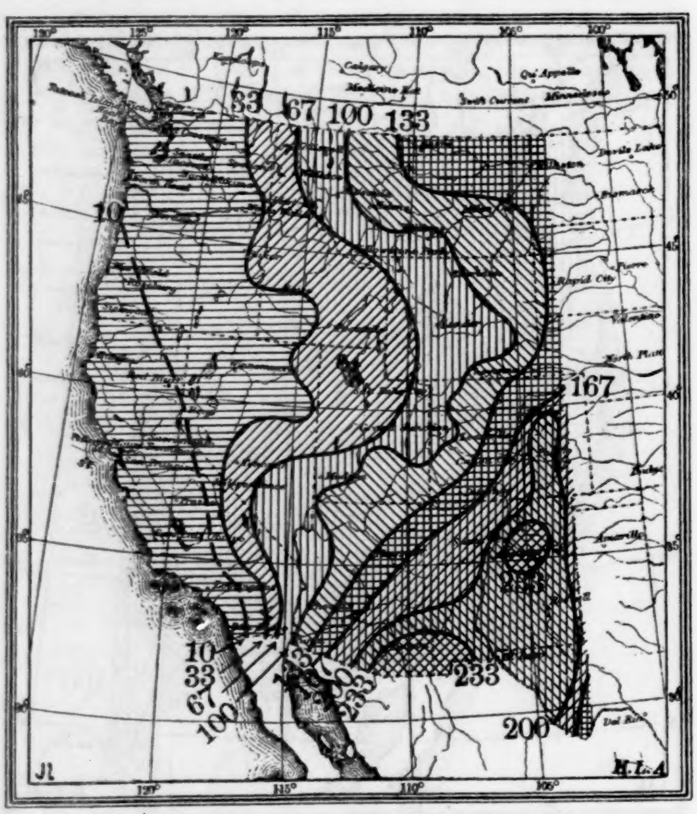

FIG. 37.—Equipluves for the western United States for July.

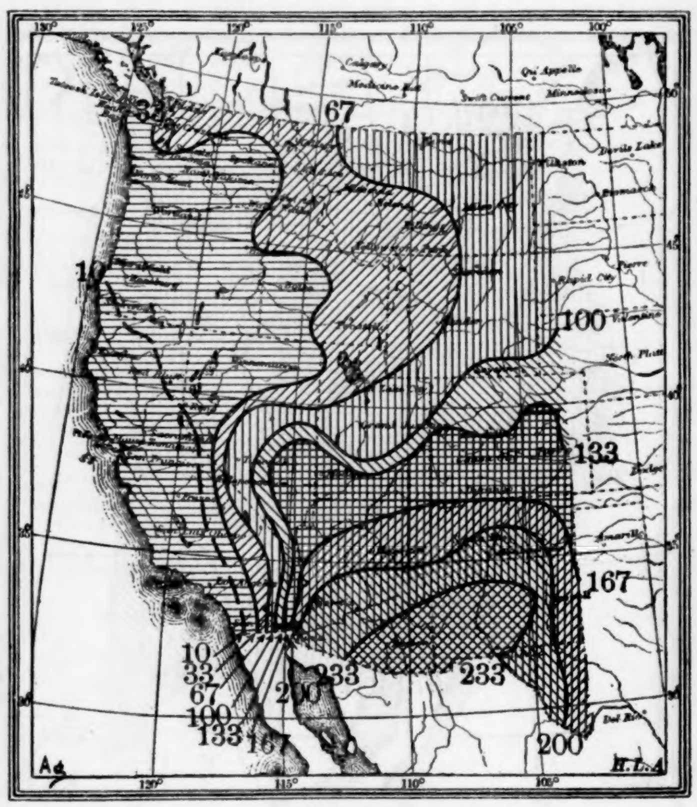

FIG. 38.—Equipluves for the western United States for August.

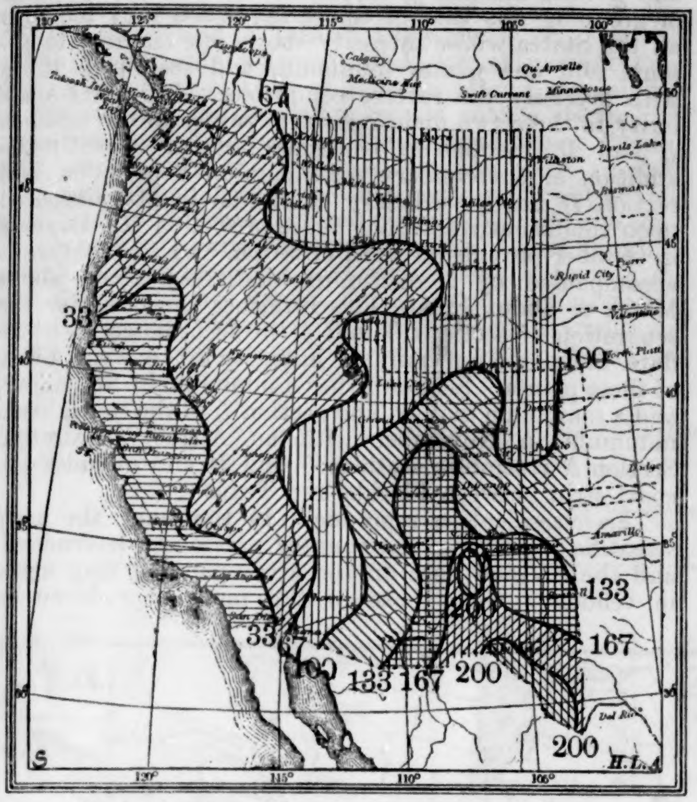

FIG. 39.—Equipluves for the western United States for September.

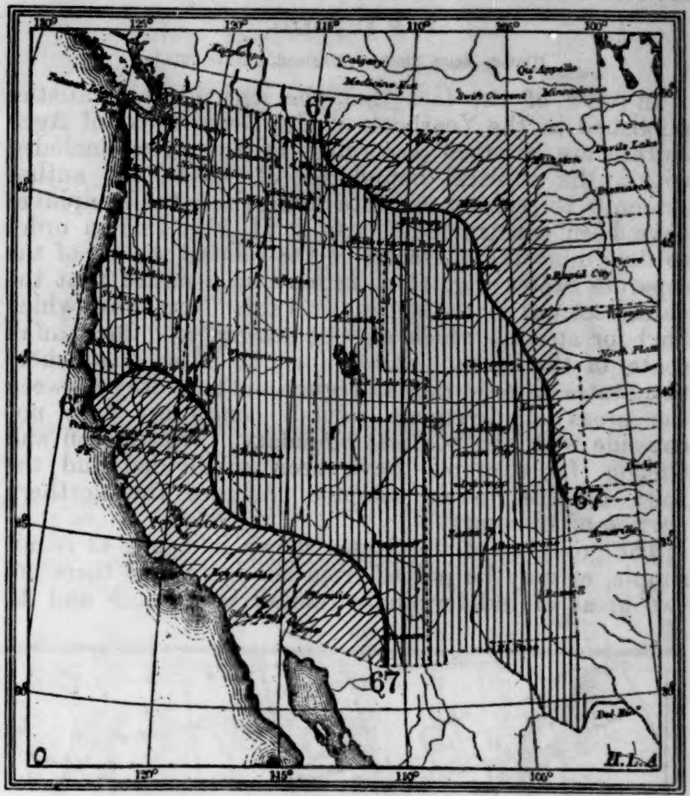

FIG. 40.—Equipluves for the western United States for October.

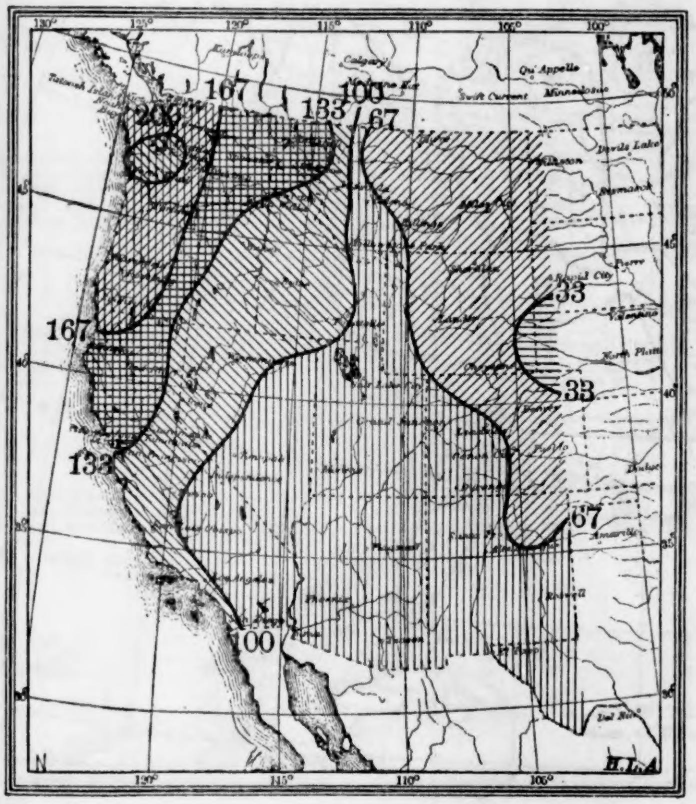

FIG. 41.—Equipluves for the western United States for November.

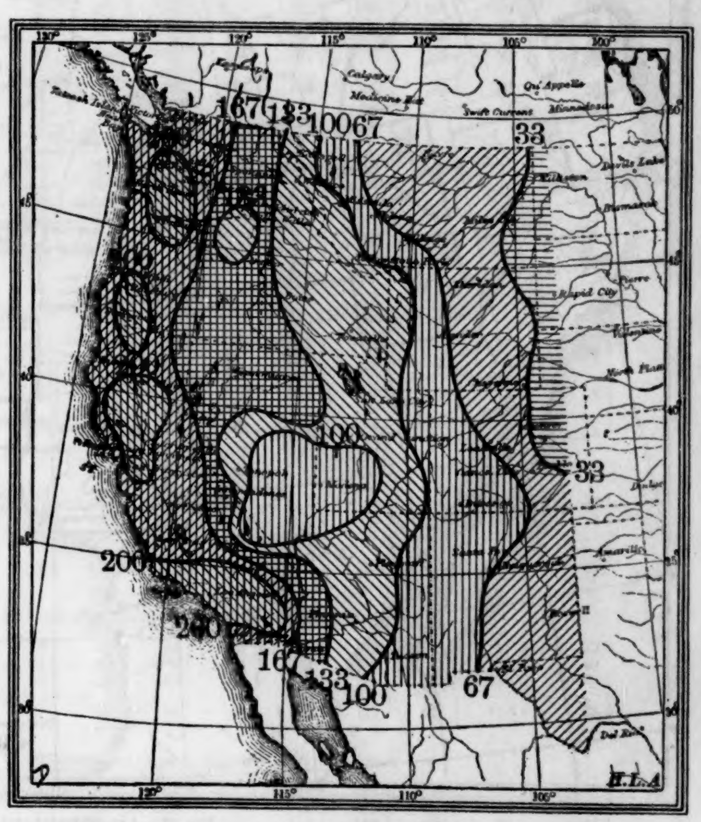

FIG. 42.—Equipluves for the western United States for December.

IV. THE RAINFALL RÉGIME OF THE SEVERAL STATES.

By B. C. WALLIS.

[Dated: North Finchley, England, Feb. 24, 1915.]

In view of the fact that the agricultural statistics published in the Yearbook of the Department of Agriculture are grouped according to the areas included within the political boundaries of States, the author attempts to regroup the data from which the equipluves have been constructed (Parts I, II, and III) in order to determine the character of the rainfall régime of the separate States (fig. 43). It may be assumed that the values set out in the appended Table 1 are those which hold for an area which may be designated "the rainfall center of the State," and it must be noted that where two States differ in rainfall régime the boundary between the areas of divergent rainfall conditions does not coincide with the political boundary. Washington and Oregon, for example, have been subdivided and the Iowa division herein adopted includes the northern portion of Missouri.

The grouping of the States shown in figure 43 is not simple, as may be judged from the facts that there are two areas of indeterminate rainfall sections, *F* and *M*, and a miscellaneous group, section *P*. The first basis of grouping was that of continuity; section *A* includes all the States whose intensity shows one summer maximum and one winter minimum, and section *C* those with precisely the reverse conditions. A general similarity to these two main regions gave rise to the sections *B* and *D*. Section *B* resembles section *A* with the addition of a secondary maximum in September, and section *D* has a secondary maximum in May imposed upon conditions resembling those of section *C*. Dryness in October provided a third criterion, and this feature is accompanied by a maximum that may come about March or about June. This furnishes the basis for the separation of sections *G* and *H* in accordance with the date of maximum rainfall intensity at one or other of these points. Section *K* has a minimum in November, and a maximum in July, and section *L* to the south has a minimum in November with an August maximum. Section *N* resembles sections *G* and *H* and includes the coast strip between Florida and Texas.

This classification reproduces, in the main, the more scientific divisions of the country previously determined, and the division lines on the accompanying map agree in tendency with those of the maps reproduced in

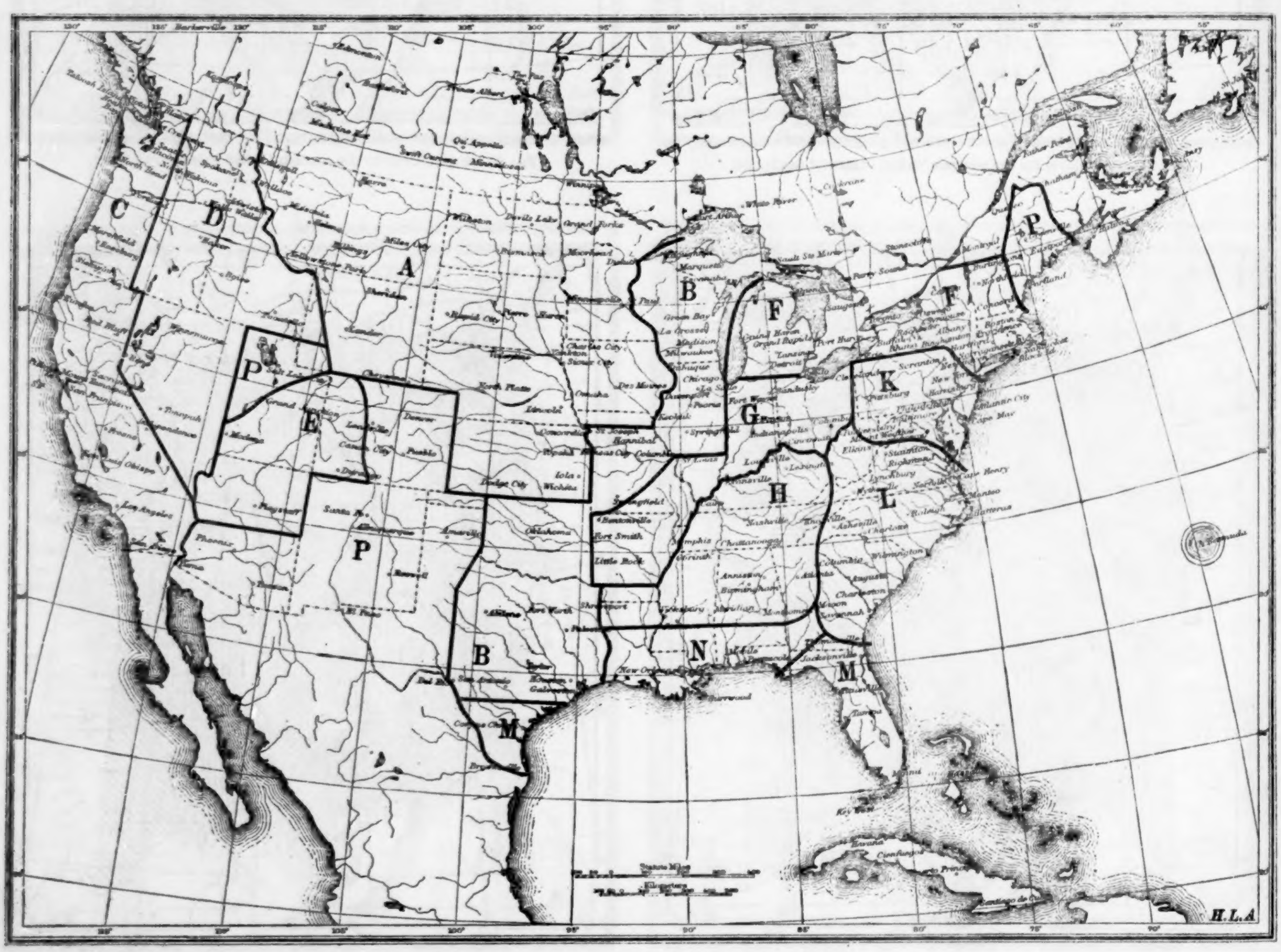

FIG. 43.—Approximate grouping of States as rainfall sections.

figures 8 (p. 16) and 26 (p. 171). The main features of each of the sections treated in detail in Table 2 are briefly summarized in Table 1 following.

The relationship between total annual precipitation and range of intensity is of interest. Down the middle of the country the rainfall increases with a decreasing range (sections *A* and *B*); in the far west, where Pacific influences govern the situation, on the coast rainfall decreases with an increasing range (section *C*), but inland both tend to decrease together (section *D*); and the conditions along the eastern coast (sections *K*, *L*, and Florida), as well as those along the next strip inland (sections *G*, *H*, and *N*), are quite different, since rainfall and range increase together. The diversity of the rainfall conditions of the United States could scarcely be better illustrated than by these facts.

TABLE 1.—*Summary of the rainfall régimes of the several States.*

Sections (fig. 43).	Months bringing— Principal maximum intensity.	Principal minimum intensity.	Average precipitation.	Range of intensity.
			Inches.	*Pl. coef.*
A	June	January	23	161
B	June	January	33	96
C	January	July	31	194
D	January	July	13	117
E	February	June	14	112
F	July	January	38	34
G	May	October	42	57
H	March	October	50	65
K	July	November	44	39
L	August	November	48	75
M	September	January	25	142
N		October	55	85

TABLE 2.—*Pluviometric coefficients for the "rainfall centers" of the different States; and the sections shown in figure 43.*

States.	September.	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	Total annual precipition.	Range of intensity.
A. SINGLE SUMMER MAXIMUM.													*Inches.*	*Pl. Coef.*
North Dakota	97	66	44	36	*33*	45	68	107	150	**243**	165	146	18	210
Minnesota	136	96	45	38	*32*	36	65	109	156	**188**	156	143	28	156
Montana [1]	91	70	77	*63*	71	*63*	76	90	195	**216**	112	76	14	153
South Dakota	90	72	38	34	*31*	37	84	139	167	**223**	152	133	21	192
Iowa [2]	129	87	54	47	*40*	47	71	113	159	**168**	152	133	32	128
Wyoming [1]	82	78	48	49	*43*	51	100	150	**225**	160	121	93	13	182
Nebraska	105	81	33	30	*27*	40	57	129	175	**206**	175	142	26	179
Kansas	118	84	46	37	*34*	51	62	116	173	**188**	160	131	29	154
Section A	106	79	48	42	*39*	46	73	119	176	**200**	147	125	23	161
B. PRINCIPAL MAXIMUM, *May* OR *June*; SECONDARY MAXIMUM, *September*.														
Wisconsin	**133**	98	67	54	*49*	51	74	104	144	**156**	148	122	31	107
Northern Illinois	**119**	73	81	*67*	69	77	97	104	**139**	136	128	110	36	72
Central Missouri	**114**	76	70	*60*	*60*	72	92	115	152	**155**	128	106	39	95
Oklahoma	**119**	94	71	52	*43*	50	77	117	**213**	141	125	98	32	170
Northern Texas	**114**	91	85	73	*65*	71	81	123	**162**	141	108	86	29	97
Central Texas	**126**	94	99	84	84	84	*73*	115	**135**	124	96	86	34	62
Section B	120	88	79	65	*62*	68	82	113	**158**	142	122	101	33	96
C. SINGLE WINTER MAXIMUM.														
Western Washington	70	91	**193**	188	148	139	109	87	71	56	*23*	25	47	170
Western Oregon	50	85	166	**197**	184	166	132	78	67	46	15	*14*	42	183
Northern California	22	66	130	198	**231**	204	183	88	55	18	*2*	*2*	36	229
Central California	22	62	115	189	**247**	202	215	88	51	8	....	*1*	18	246
Southern California	46	56	91	196	**217**	**217**	211	68	42	*8*	17	31	11	209
Section C	42	72	140	193	**205**	186	170	82	57	27	*11*	15	31	194
D. PRINCIPAL MAXIMUM WINTER; SECONDARY MAXIMUM, *May*.														
Eastern Washington [3]	64	83	**174**	147	160	133	99	78	**104**	80	40	*35*	18	139
Eastern Oregon	72	83	131	129	**142**	141	136	91	**121**	86	35	*33*	15	109
Southern Idaho	56	90	107	120	136	144	**151**	100	**126**	89	*36*	42	13	115
Nevada	43	73	95	150	**172**	162	132	114	**123**	72	*29*	35	8	143
Section D	59	82	127	136	**152**	147	129	96	118	82	*35*	37	13	117
E. TWO MAXIMA.														
Southern Utah	100	*78*	88	106	114	**144**	134	100	107	*27*	89	**113**	12	117
Western Colorado	120	99	*73*	88	82	105	**116**	106	104	*59*	118	**130**	13	71
Western Arizona	71	*62*	95	136	134	**170**	120	63	44	*17*	123	**164**	17	147
Section E	97	*80*	85	110	110	**140**	123	90	85	*34*	110	**136**	14	112
F. INDETERMINATE REGION OF SMALL VARIATION.														
Michigan	112	98	94	84	*82*	83	84	92	**125**	118	**123**	105	32	43
New York	102	100	88	95	*84*	89	96	88	103	119	**123**	113	40	39
New England [4]	95	96	108	89	96	107	103	*83*	98	96	**116**	113	42	33
Section F	103	98	97	89	*87*	93	94	88	109	111	**121**	110	38	34
G. MINIMUM IN *October*; MAXIMUM IN *May-June*.														
Indiana	92	*71*	106	89	78	98	112	101	124	**129**	104	96	40	58
Ohio	89	*73*	91	88	88	96	110	97	116	**129**	124	99	37	56
Southern Illinois	86	*66*	108	85	88	100	123	109	118	**126**	102	89	41	60
Southeast Missouri	94	*70*	95	81	82	95	121	111	**130**	126	106	89	45	60
Northern Arkansas	86	*64*	102	89	99	96	122	106	**140**	107	103	87	48	76
Section G	89	*69*	100	86	87	97	118	105	**126**	123	108	92	42	57

[1] Relatively few observations.
[2] Including a portion of northern Missouri.
[3] Including northern Idaho.
[4] New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut.

TABLE 2.—*Pluviometric coefficients for the "rainfall centers" of the different States*—Concluded.

States.	September.	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	Total annual precipitation.	Range of intensity.
	H. MINIMUM IN *October;* MAXIMUM IN *February-March.*													
													Inches.	*Pl. Coef.*
Kentucky	75	*59*	103	95	102	114	**128**	101	104	114	112	93	46	69
Tennessee	76	*57*	94	102	113	122	**135**	113	91	106	101	90	50	78
Northern Georgia	78	*62*	70	102	104	**149**	132	92	74	100	116	121	52	87
Northern Alabama	65	*55*	74	104	115	**142**	140	105	89	100	112	90	51	87
Northern Mississippi	72	*50*	81	109	122	131	**136**	106	88	104	109	92	52	86
Southern Arkansas	80	*66*	104	95	116	106	**129**	116	118	105	97	68	46	61
Section H	74	*58*	88	101	112	127	**133**	106	94	105	108	94	50	65
	K. MINIMUM IN *November;* MAXIMUM IN *July-August.*													
Pennsylvania	96	85	*83*	90	90	95	101	92	110	117	**128**	113	43	45
New Jersey	100	93	*89*	96	94	106	98	90	97	99	118	**120**	48	31
Maryland, Delaware, etc	97	86	*77*	93	86	105	100	93	104	120	**122**	117	41	36
Section K	98	88	*83*	93	90	102	100	92	104	112	**122**	116	44	39
	L. MINIMUM IN *November;* MAXIMUM IN *August.*													
West Virginia[5]	80	*72*	75	86	102	99	111	106	109	**135**	123	102	43	63
Virginia	96	91	*67*	89	81	102	95	94	107	122	125	**131**	44	64
North Carolina	91	78	*64*	88	82	114	100	84	97	119	138	**145**	50	81
South Carolina (inland)	94	71	*66*	84	89	136	100	84	85	124	124	**143**	48	77
South Carolina (coast)	116	79	*63*	69	77	95	86	68	88	132	153	**175**	50	112
Southern Georgia	95	71	*61*	81	82	140	108	77	73	121	140	**151**	52	90
Section L	97	77	*66*	83	85	114	100	86	91	126	134	**141**	48	75
	M. INDETERMINATE SECTION WITH TROPICAL FEATURES.													
Eastern Florida	**171**	110	*49*	50	61	72	57	52	80	142	127	129	53	121
Western Florida	157	67	*42*	56	65	79	64	49	75	180	**185**	181	54	143
Southern Texas	**201**	101	82	65	*59*	72	68	77	132	124	91	128	25	142
	N. MINIMUM IN *October;* GULF COAST SECTION.													
Southern Alabama	83	*58*	72	93	93	**140**	134	78	80	102	134	133	53	82
Southern Mississippi	93	*55*	68	91	100	**131**	122	97	75	108	**131**	129	57	76
Louisiana	112	*63*	**72**	89	80	110	79	92	76	135	**161**	131	56	98
	P. MISCELLANEOUS AREAS.													
Northeastern Colorado[6]	84	81	37	35	*28*	47	88	176	**209**	138	158	119	16	181
Southeastern Colorado[6]	81	75	40	46	*30*	47	73	156	174	131	**188**	149	16	158
Northeastern New Mexico[1]	138	70	49	46	*27*	45	36	79	131	153	**232**	195	16	205
Arizona, etc.[1]	168	100	75	60	*51*	66	*51*	62	66	100	194	**200**	12	149
Northwestern Utah	78	90	94	119	128	131	135	118	**148**	62	*40*	57	13	108
Colorado area (west)	97	76	93	136	121	153	100	40	*20*	*20*	152	**192**	13	172
Colorado area (east)	128	70	66	79	79	108	77	32	*22*	37	236	**266**	6	244
Maine	99	98	105	100	105	**121**	116	81	98	91	99	*87*	42	34

[1] Relatively few observations. [5] Similar in many respects to section G. [6] Resembles section A, with special drop in June.

METEOROLOGICAL OBSERVATIONS NEAR SCHIEFFLIN, LIBERIA, 1913-1914.

P. C. DAY, Climatologist and Chief of Division.

[Dated: Weather Bureau, Washington, D. C., Apr. 27, 1915.]

The Christian Woman's Board of Missions, at Indianapolis, Ind., a few years ago established a branch mission at Schiefflin, Liberia, at which point a series of meteorological observations have been made for nearly two years past.

From May, 1913, to October, 1914, inclusive, the observations were made by Mr. Emory Ross, and since that time by Mr. Lewis A. Hurt, both associated with the mission work in that region.

Schiefflin, the point at which the observations are made, is located on the west coast of Africa, about 20 miles down the coast from Monrovia, the capital of the Republic of Liberia, and within a few hundred yards of the Atlantic Ocean, the exact location being in latitude 6° 11′ north, and longitude 10° 33′ west.

Instruments.—The instrumental outfit consists of a set of maximum and minimum thermometers and a rain gage. The thermometers are after the Weather Bureau pattern, made by the Taylor Instrument Co., of Rochester, N. Y., and compared with their standard. They are exposed in a large perforated box, protected from the weather by a good roof, and are at an elevation of about 5 feet from the ground. The rain gage is of the Glaisher pattern, manufactured by Short and Mason of London, England, and consists of a container 8 inches in diameter with a funnel cover of the same dimensions furnished with a curved tube to prevent evaporation. The graduated measuring jar reads to hundredths of an inch and holds ½ inch of rainfall. The gage is supported in a box fastened to a short post and the mouth of funnel is about 3 feet above the ground.

The instruments are located in a considerable cleared space about 25 feet above sea level, and opening toward the ocean. The adjacent country is both wooded and open.

The summary presented herewith embraces the principal numerical values of temperature, precipitation, and weather for each month, and should form a valuable basis for the study of the climate of that little known region.

Climate.—The following are a few of the more important features brought out by an inspection of the original records.

The climate of this place, only a few degrees from the Equator, is essentially equatorial, but doubtless greatly

modified by its proximity to the ocean and the prevalence of the alternating land and sea breezes. Although north of the Equator the highest day temperatures occur in the period December to May and the lowest during July to September. Night temperatures are fairly uniform throughout the year except for January and February when they are considerably lower than during the remaining months, probably on account of increased radiation due to absence of clouds and the drier condition of the atmosphere.

January has the greatest range between the day and night temperatures while the least occurs during the period June to September. The maximum temperature did not go higher than 91° during the entire period of 20 months observations and reached that point but 8 times.

Minimum temperatures range within a few degrees of 70° throughout the year, except from December to February, when they occasionally fall below 60°. A minimum temperature of 66° on the night of December 8, 1913, is referred to by the observer as a very cold night although in the following January readings as low as 58° were recorded.

The unusually low temperatures during these months are reported as occurring with dry north winds probably blowing from the Sahara, although their dry character is doubtless much modified during their passage over the intervening forests.

The characteristic wet and dry seasons of the Tropics are well defined in this section of the African coast. January probably has the least rainfall, only 0.10 inch falling during that month in 1914. December, February, and March likewise appear as months of light rainfall, the total for the four dry months constituting less than 3 per cent of the annual.

The wet season prevails from May to November, during which period rains are frequent and often heavy, as much as 6 to 8 inches falling in a single period of 24 hours. Considerable variation exists in the amounts during the same months of different years; for instance, June, 1913, had a total of 27.48 inches, while the same month of 1914 had slightly more than 50 inches. The total rainfall for the 12 months, July, 1913, to June, 1914, was more than 200 inches, a record probably equal to that of any other point along the coast.

During the rainy season precipitation is of almost daily occurrence, and cloudy weather prevails continuously for long periods. From July to October, 1913, inclusive, 123 days, rain occurred on all but 17 days.

During the drier period of the year there is much clear and pleasant weather, and the land and sea breezes occur at regular periods, the land breeze from about 11 p. m. to about 9 a. m. and the sea breeze for the remainder of the 24 hours.

TABLE 1.—*Summary of meteorological observations at Schiefflin, Liberia, May, 1913, to December, 1914.*

Months.	Temperature.							Precipitation.			Weather.		
	Mean maximum + mean minimum ÷ 2.	Mean maximum.	Mean minimum.	Highest.	Lowest.	Greatest daily range.	Mean daily range.	Total.	Greatest in 24 hours.	Number of days with 0.01 inch or more.	Clear.	Partly cloudy.	Cloudy.
1913.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	Inches.	Inches.	Days.	Days.	Days.	Days.
May	80.0	87.7	72.3	91	68	21	15.4	9.93	2.58	17	8	14	9
June	78.7	85.3	72.1	90	69	18	13.2	27.48	4.38	24	1	4	25
July	77.7	83.4	72.0	88	68	16	11.4	30.69	6.24	29	0	0	31
August	77.0	81.7	72.3	86	71	14	9.4	30.07	6.16	25	3	11	17
September	76.6	81.7	71.6	85	68	14	10.1	23.90	3.06	26	5	9	16
October	78.6	84.7	72.6	89	70	17	12.1	24.35	4.52	26	12	14	5
November	79.6	86.6	72.5	89	70	18	14.1	8.74	2.35	15	7	17	6
December	79.9	87.8	72.0	91	66	22	15.8	1.74	0.74	4	13	11	7
1914.													
January	77.8	87.5	68.2	91	58	31	18.7	0.10	0.10	1	16	10	5
February	78.9	87.6	70.2	91	65	24	17.8	1.84	1.84	1	15	8	5
March	80.1	88.2	72.0	91	68	21	16.2	1.29	0.48	6	18	8	5
April	79.8	87.9	71.6	91	70	19	16.3	8.76	2.43	14	25	5	0
May	79.4	87.3	71.6	90	69	20	15.6	19.70	3.85	23	8	22	1
June	78.0	82.6	73.3	87	70	15	9.3	50.35	7.50	29	5	13	12
July	75.3	79.3	71.3	84	69	12	8.0	13.25	3.20	23	3	6	22
August	75.8	80.3	71.3	85	68	17	8.9	14.46	2.95	20	6	9	16
September	76.8	81.6	72.1	84	69	13	9.5	26.43	3.04	28	6	14	10
October	78.1	83.6	72.6	87	69	14	11.0	31.66	4.02	30	7	14	10
November	78.7	85.0	72.4	88	69	17	12.6	13.90	2.50	23	12	14	4
December	79.8	88.2	71.5	90	61	28	16.7	4.43	2.77	8	14	15	2

MONTHLY WEATHER PERIODICITY.[1]

By VLADIMIR KÖPPEN.

[Translated from Meteorologische Zeitschrift, April, 1915, 32:180-185—C. A., jr.]

It is wonderful with what stubbornness does persist the belief that the moon must in some kind of a manner exercise a decisive influence on the weather and that the wicked, narrow-minded scholars simply refuse to recognize it. It is claimed that scholars refuse to investigate the matter, contenting themselves with discrediting the statements made by the "Unbiased" who do not belong to the profession.

Now, there could be no more welcome present to meteorologists, particularly to those who are charged with the duties of a forecaster, than such a simple key to the confusion that surrounds the weather's changes. How much pleasanter the task of weather forecasting if, by a glance at the moon's position as given in an astronomical ephemeris, one could ascertain the actual tendency of the weather to improve, to grow worse, perhaps even the tendency to a given pressure distribution, instead of having painfully to acquire a knowledge concerning the behavior of lows, etc., that still leaves so many possibilities open.

For this very reason there actually are no small number of scientific studies of a possible lunar influence on the weather. To be sure, the instigators of the repeatedly reappearing lunar systems of weather prophecy are usu-

[1] Preliminary communication; the full memoir will appear in the Archiv der Deutschen Seewarte.—*Author.*

ally wholly ignorant of the fact that, when there is such a complex cooperation of many causes which can not be sifted by experiment, the truth of the matter can only be demonstrated by discussing a sufficiently large amount of observational material by the aid of correct statistical methods. Such people prophesy wildly on the strength of some coincidence. They are usually quite lacking, also, in the proper self-criticism; in their eyes everything confirms their assumptions, and they willingly surrender themselves to their agreeable self-deception.

Nevertheless, the application of correct methods has brought out several points wherein there are signs of a lunar influence, and these must be further investigated. On the one hand these signs indicate an atmospheric tidal movement, very slight, to be sure, and of infinitesimal effect upon weather and wind, as are the daily barometric variations in any case. On the other hand they point to more or less considerable fluctuations of about one month's duration; the regularity of these swings leaves it an open question whether they belong with one of the periods of the lunar revolution or of the sun's rotation, for these have similar durations.

At present we will consider only these monthly variations. So far we have two fluctuations apparently so well supported by observations that it is desirable to analyze them exhaustively—viz, (1) the strong pressure variations of the synodal month falling in the last month of our year, discovered by G. Meyer and K. Seemann [2] in 1890; and (2) the variation in thunderstorm frequency also accompanying the synodal month, discovered by Luedicke [3] in 1875. The closer investigation of these two periodicities seems promising, because repeated investigations of long series of observations by different students have revealed their occurrence. Seemann and Meyer found the first while working independently on the series 1869–1886 and 1876–1889. After Luedicke had found the second case, it was again discovered (with a smaller amplitude, to be sure) in 1885 by the present writer [4] and later by Richter,[4] Hazen, Meyer, Gruss, Polis, and others,[5] as also in 1898 by Ekholm and Arrhenius.[6] I have sought to investigate these two problems as exhaustively as possible, utilizing all the published observations. After laying aside the consideration of the first problem, 18 years ago,[7] because of the internal contradictions in the results, the work has again advanced so far during the past months that it seems suited for at least a preliminary notice.

Seemann and Meyer had shown that during the years they investigated, the pressure over central Europe in the months September to January stood, on the average, almost 10 mm. (!) lower in the first days following full moon than it did in the first days after new moon. It remained to determine both the areal extent of this phenomenon (it could not possibly embrace the whole earth) and its behavior during other periods, for Seemann had found that it did not appear on the average during 1844–1875.

In order to contend with the tremendous amount of material on hand, it was necessary to employ the very simplest methods. Consequently no means were computed, but I simply counted the cases of positive and negative pressure departures from certain thresholds (Schwellen). Since 1876, and often earlier, the published meteorological records group the daily values into 5-day periods; it was therefore most convenient to group the counts into 5-day sections, the first new moon or full moon of the month falling in the middle of the first 5-day section and the following five coming in succession thereafter. This order was adhered to in each month, thus eliminating the shift of the synodal month so far as it was present. An example will illustrate the method:

TABLE 1.

THORSHAVN, 1885. Schwellen: 765 mm., 740 mm.

[Three observations daily.]*

Pentads..	1		2		3		4		5		6	
Schwellen.....	>65	<40	>65	<40	>65	<40	>65	<40	>65	<40	>65	<40
● 8 Oct.	......	......	12	......	10	......	......	2	2	6	......	2
● 6 Nov.	......	......	3	1	2	......	2	......	......	5	......	10
● Dec.	4	2	5	4	......	......	3	......	......	4	......	14
Sums....	4	2	20	5	12	0	5	2	2	15	0	26
	(a) 24−7=+17						(b) 7−17=−10					

* The three observations daily thus gave 15 observations in each pentad.

The compilation for 1875–1894 was the first made; it completely confirmed Meyer and Seemann's results and gave sharper limits for them. In the 20-year mean there regularly appears a standing pressure wave during these three months. Its crest appears over Scandinavia a few days after new moon, while its trough lies over Scandinavia and the North Sea a few days after "new moon" [full moon ?]. In Norway this rule is so strongly marked that the difference (*a*) − (*b*) at Bodö during these 20 years was almost always positive, as is shown by the following set of numbers:

TABLE 2.—*Difference* (*a*)−(*b*) *at Bodö, Norway.*

1875,	9,	1880,	8,	1885,	7,	1890,	24,
1876,	46,	1881,	13,	1886,	14,	1891,	1,
1877,	12,	1882,	61,	1887,	6,	1892,	1,
1878,	−5,	1883,	21,	1888,	37,	1893,	14,
1879,	19,	1884,	1,	1889,	15,	1894,	−12.

The amplitude of this variation decreases in all directions from Norway; in southern Europe (San Fernando-Lesina), in the Ural and in West Greenland the difference is almost zero, while in Siberia it has the opposite sign signifying that on the average the pressure after full moon was there higher than after new moon. It is to be expected that such a compensation occurs somewhere, and it is a cause for regret that owing to the lack of published daily meteorological observations from America this phenomenon can not be traced farther.

As one rarely employs more than 20 years of records in such an investigation it might appear that the above has established an interesting periodicity. A computation of the errors would give a small probable error for the results. Nevertheless the periods before 1875 are wanting, as already stated. The question now arises: Does this appearance and disappearance form part of a longer periodicity? If this is the case, the result is a valuable one which might be used to a certain degree in practical weather forecasts. If the longer periodicity is wanting, then we face a strange accident from which no conclusions can be drawn for the future.

In resuming the investigation of this question, I therefore set myself the task of tracing this questionable relation through as many years as possible, and called on Dr. Burchard and Capt. Bachmann of the Deutsche Seewarte to assist me. I had already been struck by the fact that the magnitude of the variation, after being somewhat smoothed, seemed to point to a 6-year fluctuation. The recent beautiful results of the 11-year temperature period and Peterson's suppositions regarding the relation between sun-spot period and moon [8] encouraged me to

[2] Meteorologische Zeitschrift, November, 1890, **7**: 427.
[3] Ztschr. d. Oesterr. Ges. f. Met., Wien, September, 1875, **10**: 281.
[4] Meteorologische Zeitschrift, January, 1885, **2**: 34–37; 307–310.
[5] *See* Namen- und Sachregister *of the* Meteorologische Zeitschrift.
[6] Handlingar, Svenska vetensk. ak., **31**, No. 2.
[7] A brief communication on that portion of the investigation which deals with the Seemann-Meyer period as seen in the "Synoptischen Karten vom Nordatlantischen Ozean," appeared in Ann. d. Hydr. u. mar. Met., April, 1896.

[8] Annalen d. Hydr. u. mar. Meteorol., 1914: 214.

group my figures also according to the 11- and the 11⅛-year periods. This treatment of European figures for the interval 1844–1912 yielded the following terminal sums for 11 years beginning with the mean minimum year of the sun spots:

Year 0	I	II	III	IV	V	VI	VII	VIII	IX	X
−1	5	11	4	1	0	7	−12	16	11	−15

Thus there are apparently two variations lasting, alternately, 8 and 3 years, which together gave the impression of a 6-year periodicity. In this connection it is noteworthy that the indicated period is not of the type 3, 8, 8, 3, 8, 8, . . . , summing 19 years, or the known lunar period of 19 or 18.6 years; but is rather of the type 3, 8, 3, 8, 3, . . Since the lunar phases return to approximately the same dates in 3, 8, and 11 years as well as in 19 years, the predominance of 3 and 8 year intervals might still indicate a cooperation of lunar and solar influences.

Unfortunately, however, all these clues are lost when one attempts to trace them through earlier years also. Useful barometric observations in Europe have been published for Basel since 1755 and for Vienna since 1775. I present here in Table 3 [A] the 10-year sums of the counts for 140 years of barometric observations at Vienna, simply to illustrate the behavior of the pressure. Pentad 1 begins two days before new moon; every figure is based on 30 pentads or 150 days.

TABLE 3 [A].—*The barometric march of the synodal month at Vienna (October to December) shown by means of the differences between the number of high and the number of low barometer readings.*

Years.	Pentads.					
	1	2	3	4	5	6
	●			○		
1775-1784	6	2	5	− 9	9	−14
1785-1794	−10	4	4	− 4	11	− 6
1795-1804	22	− 7	−15	5	−10	6
1805-1814	2	7	−47	16	20	3
1815-1824	8	−22	−20	19	8	5
1825-1834	21	16	−35	−11	0	9
1836-1844	23	28	5	−25	−31	− 1
1845-1854	22	1	6	−27	0	1
1855-1864	−34	− 2	29	1	− 8	16
1865-1874	25	− 6	−20	19	−29	14
1875-1884	51	− 3	0	−16	−23	− 7
1885-1894	0	18	− 2	−21	3	4
1895-1904	−12	−16	−24	28	20	4
1905-1914	−36	21	− 2	18	5	− 6

By properly selecting the years all kinds of "lunar influences" may here be "demonstrated" by means of a material that would ordinarily be regarded as quite adequate therefor, i. e., with 10 to 20-year means. One may find here the simple pressure oscillation of the years 1835 to 1844, or the quite unsymmetrical one of 1895 to 1904, or the irregular double oscillation of 1865 to 1874 and 1905 to 1914, and again the displacement of the extremes throughout the month.

Since, however, the pressure excesses of pentads **1** and **2**, as compared with 4 and 5 (appearing in the years 1875 to 1894 and also in 1835 to 1854) are probably the most interesting it is not inappropriate to present in Table 4 [B] the algebraic sums of these differences for the barometric observations at 1 to 10 European stations for each of the 60 years 1755 to 1814. The numbers before 1775 relate to Basel, those following to both Basel and Vienna; from 1781 on they include stations of the Mannheim Society until the latter ceased in 1792. London is included from 1795 on, and after 1809 I have always used at least 4 series which increases to at least 6 after 1822. From the superfluity of more recent observations I have selected only those places that gave the monthly variations from 1875 to 1894, which were mentioned at the beginning of this paper (p. 180a), i. e., from the region bounded by the line Vardö-Archangel-Petersburg-Warsaw-Vienna-Geneva-London-Styckisholm-Vardö, which also embraces the stations furnishing the older observations.

In Table 4 positive figures indicate that in the region above delimited, the barometer was higher in the 10 days at and after new moon than in the 10 days at and after full moon, on the average for the last three months of the year given. The negative figures indicate when the opposite was the case.

TABLE 4 [B].—*Relative numbers for the excess of the pressure at and after the time of new moon compared with the pressure at and after full moon.*

Years.	0	1	2	3	4	5	6	7	8	9	10-year sums.[1]		
											Arithmetic.		Algebraic.
											+	−	
1750						− 2	4	−12	9	−29	13	43	− 30
1760	−23	48	−12	4	− 7	33	15	29	3	3	113	42	71
1770	−45	−21	−25	− 9	−25	−13	47	− 9	44	5	96	137	− 41
1780	4	−11	−25	−14	−12	−38	21	−14	3	4	11	114	−103
1790	9	22	−13	9	−11	11	10	− 3	9	− 6	70	33	37
1800	56	1	−30	−21	−16	−14	−12	−22	−19	− 4	57	138	− 81
1810	− 5	− 4	− 2	27	1	37	7	6	− 1	−11	78	23	55
1820	3	−45	− 5	−15	− 4	13	−24	3	− 6	0	19	99	− 80
1830	11	−22	5	− 4	0	4	− 8	−13	12	− 6	32	53	− 21
1840	29	−33	36	12	−33	− 3	−27	− 9	− 2	21	98	107	9
1850	33	− 9	10	10	−11	5	− 5	4	25	−38	87	63	24
1860	−15	−11	−28	− 5	32	− 8	−13	5	7	16	60	80	− 20
1870	12	22	5	−21	−15	23	20	10	− 2	8	100	38	62
1880	16	− 4	21	17	0	12	35	3	14	5	123	4	119
1890	3	6	9	3	7	20	−17	11	21	−30	80	47	33
1900	2	−15	− 3	7	−18	− 6	17	−23	20	14	60	65	− 5
1910	−21	−20	11										

[1] Computed and added by the translator.

Again, on looking through Table 4 one finds many apparent regularities that persist through a certain series of years, but there are none that run through the whole period of 158 years. The 10-year sums at the right-hand side of Table 4 present, between 1875 and 1895, a very significant series of figures having like sign almost without interruption. Their parallel is not to be found elsewhere in this table, among either the positive or the negative values. There is almost no trace of a long-period recurrence of this series.

What shall one think of such confusion? This apparent monthly pressure change which persists through a certain number of years, together with its disappearance or shifting of its maxima and minima, is meaningless to us. Should we perhaps ascribe it, not to the lunar motions but rather to the rotation of the sun, on whose surface active (e. g., hotter) areas can persist for a series of years and then disappear? But what evidence have we for such an explanation?

Many adherents of the moon theory will say: "Well, then, if the synodal revolution does not cause it, then perhaps one of the others does." But at least one of these other motions, the periodic or sidereal, is contained in these figures because they apply only to one season of the year and the relation of the two periods is the same at intervals of a year. The investigation seems still more unpromising if carried out for the other seasons, because Meyer and Seemann found no regularities in them either. Nevertheless I have carried it out for them also, although for only a few observing stations, but shall not here notice the results; besides, they have turned out negatively.

However much it is to be regretted that these extensive comparisons fail to reveal any regularities, their publication will at least furnish an arsenal of material for use in the exact testing of the perennial crop of new variants on the contention that the weather is controlled by our obviously and oh, *so* innocent satellite.

INFLUENCE OF THE MOON ON WEATHER.

In connection with the interesting preliminary report by Director Köppen, translated on another page, it may not be out of place to here mention an elaborate discussion of the moon's influence on weather by Dr. Gotthold Wagner.[1] His memoir begins with a thorough discussion of the history of the development of a belief in the moon's weather influences, tracing the idea from its earlier forms preceding Babylonian astrology, up through Greek astrology and "meteorology" until the Ptolmaic astrology passes over into the modern ideas of weather forecasting by suppositious lunar influences. The second half of the memoir presents in some detail a critical summary of modern and truly scientific investigations regarding possible lunar influences on terrestrial weather and concludes with the following paragraphs.—C. A., jr.

We have here refuted the popular belief that the lunar influence is sufficiently strong to permit of its direct, unaided observation, and that one can even deduce weather forecasts from it. The repeated assertion that the popular belief is based upon observation is incorrect. This belief is rather the offspring of a primitive religion, and it has been forced upon the people by a science that imagines it can replace exact observations by logical speculations. This idea must be in the minds of those who, believing in the supposed wisdom of the populace, continually repeat the attempts to construct a system of weather prophesies. They scarcely succeed in devising a system that has not previously been tried in whole or in part, and has therefore already been refuted.

The recognition of this fact is not without significance for science also. Thus if, for example, it has been shown that the very nature of its origin vitiates the "rule" that the moon causes humidity or moisture, then there is no use of again refuting it by means of painfully compiled observations. Simultaneously the incentive to similar investigations regarding temperature, cloudiness, and precipitation vanishes, and all the more readily because all such efforts in the past have failed to attain any satisfactory results.

On the other hand, compilations of atmospheric pressure observations have shown that there is at least a possibility of discovering laws of a tidal movement in the atmosphere. All the compiled observations for tropical latitudes agree in showing a very regular, though not very large, semidiurnal wave. In higher latitudes the tidal features seem to become more complicated. The semidiurnal wave seems to be displaced by a wholly diurnal wave. This calls for new, extensive investigations which shall, if possible, trace the march of the atmospheric tides along a sector of a meridian. It is not improbable that such a procedure would reveal such conditions, as may be inferred from the works of Garrigou-Lagrange and Poincaré.

Studies of the influence of the moon in the individual months are considerably less certain and satisfactory; they do, indeed, suggest a certain regularity, but furnish one with no certainty. For his part, the writer would suppose that the ground for this uncertainty arises from the manner of formulating the problem and the methods of study. Heretofore the monthly pressure-march has been studied through the daily means, while assuming as a matter of course that the moon modifies the daily means. What would be the result if, in the course of a month, it were only the amplitude and the phase of the lunar daily tide that varied? Were this the truth, then compilations of daily means could reveal regularities only in a strongly masked form, if they could show at all.

My own compilations have shown that we are quite justified in doubting the propriety of the above assumption. Daily mean pressures at Batavia for 26 years show not the slightest regularity in curves, and an investigation of the change of the atmospheric tides gave a clearly marked regularity in the change in phase of the amplitude. These results, Garrigou-Lagrange's discovery that there was an extensive change in the tides such that in the course of a siderial month they were converted into their precise opposites, and further the published compilations of the Batavia observations, make it necessary to change the method of compilation—resulting in an unexpected increase in labor. First of all one must investigate simultaneously the changes in the lunar-day tide and the daily mean for each of the different months, determining which of the two elements is the variable. At first sight this seems to imply an extraordinarily great increase in labor; but it appears practicable if one applies a method customarily followed in computing the marine tides.

First, the observations made according to solar time are transformed into lunar time. Hereby it is quite sufficient to use in place of a lunar day 24 successive solar hours, only taking care to begin the count with the upper culmination. The observations are set down on strips, each of which stands for a lunar day; each strip must show the year, the day, and the hour of the culmination; also when possible, declination, moon's phase, perigee and apogee. Such a strip would read as follows:

1905, Oct. 5.	$12^h+22°$A.		3.4 mm	3.7	. . .
1905, Oct. 6.	$13+20°$.		4.2 mm	4.5	. . .

With this arrangement the investigation is now readily carried out. First, adding the figures for the lunar days as they thus stand one beneath the other, there results the mean march of pressure for a lunar day proper, that is, the regular tidal movement. Since the horizontal lines would be added in any case for checking, one also secures at the same time the daily mean.

To study the siderial month, it is only necessary to select the days having the same declination, place them one below the other and add. Thus results the lunar daily wave for each declination and simultaneously the mean of the lunar day for each declination. In this connection it might prove worth while to sort the days of the same declination into those when the moon is nearing the lunistice or the Equator.

In just the same way the daily strips may be arranged to study the anomalistic and the synodial months.

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[1] Wagner, Gotthold. [Influence of the moon on the weather.] Beiträge zur Geophysik, Leipzig, 1913, 12., 2. Hft., p. 277-328; 4. Hft., p. 528-587.

BEAUFORT WIND SCALE AND NEW RUSSIAN EQUIVALENTS.

B. GALITZIN, Director.

[Dated: Petrograd, Apr. 10, 1915. Received: May 17, 1915.]

The Central Physical Nicholas Observatory, Petrograd, announces that beginning May 1, 1915 (new style) the following table of equivalents for expressing the force of the wind, as observed by means of the Wild tablet anemometer, will be used by the Russian meteorological stations. The table has been prepared in conformity with the decisions of the International Meteorological Committee meeting at Rome in 1913; it is based on the English table.

Wild anemometer indications.		Beaufort scale of wind force.	Wind velocity.
Light tablet.	Heavy tablet.		
			M./sec.
1	1	0	0
1–2	....	1	1
2 & 2–3	1–2	2	2–3
3 & 3–4	2	3	4–5
4, 4–5 & 5	2–3 & 3	4	6–8
5–6 & 6	3–4	5	9–10
6–7	4	6	11–13
7 & 7–8	4–5 & 5	7	14–17
8	5–6 & 6	8	18–20
Above 8.	6–7	9	21–24
....	7	10	25–28
....	7–8	11	29–33
....	8	12	34 & over.

NOTES.

Private advices from Graz, Austria, state that the professor of meteorology in the University of Graz, Dr. Heinz von Ficker, served as an officer in the military aeronautic corps operating the captive balloons in Przemysl during the siege of that fortress by the Russians. He was among those who left the fortress in free balloons shortly before its surrender to the Russians; it is believed that his balloon was driven within the Russian lines and that its crew landed safely but were captured by the enemy.

Under date of April 9, 1915, the "Wolfenbüttler Kreisblatt" announces that the Duke of Braunschweig has conferred the title of Geheime Hofräte on the well-known leaders of modern research in atmospheric electricity, Profs. Julius Elster and Hans F. C. Geitel.

The Weather Bureau is advised that Dr. Y. Wada retired on April 8, 1915, from the directorship of the Meteorological Observatory of Korea at Chemulpo. His successor is Dr. T. Hirata, formerly chief of the forecasts division of the Meteorological Service of the Government General of Korea.

SECTION III.—FORECASTS.

STORMS AND WARNINGS FOR APRIL, 1915.

By EDWARD H. BOWIE, District Forecaster.

[Dated: Weather Bureau, Washington, D. C., May 13, 1915.]

On the 1st of the month a low of considerable proportions was over the Grand Banks and a high-pressure area of great magnitude central over Manitoba dominated weather conditions over almost the entire country, frosts being reported in the East Gulf and South Atlantic States, warnings for which had been previously disseminated. A high center broke away from the main high over Manitoba and passed eastward off the Jersey coast.

On the evening of the 1st the following special forecast was issued:

> The prominent features of the weather map on Thursday were a general increase in pressure over the north Atlantic Ocean and a decrease in pressure over the western Canadian Provinces. This is the first time since the middle of March that the pressure has assumed this distribution, and it logically follows that the prolonged period of cool weather that has been general east of the Rocky Mountains during the past two weeks will be succeeded by a period of temperatures above the seasonal average over the eastern half of the country beginning the early part of the coming week.

On the morning of the 2d a low was central off the southwestern coast of Florida and advices were issued to Florida coast stations. During the afternoon advices were issued to South Atlantic ports and in the evening extended northward to Cape Cod. On the 3d the storm was near Hatteras, with lowest reported barometer 29.10 at Manteo, N. C. Storm warnings were extended to Eastport and heavy snow warnings issued for portions of coast States from Maryland northward. The storm passed northeastward up the coast and on the 5th was over the Grand Banks. Precipitation was confined to sections near the coast, and heavy gales were reported, with some damage to shipping.

A portion of the high that was over Manitoba on the 1st passed southward to the West Gulf coast and thence eastward across the Gulf States causing frosts in the Gulf and South Atlantic States, warnings of which were previously issued.

In the trough of a low-pressure area that appeared over Alberta on the 2d, a secondary developed over the northern Plains States on the 4th which passed eastward and northeastward. The showers attending this disturbance were confined to the Lake Region, the Ohio Valley and North Atlantic States.

It was followed by a high-pressure area which was an offshoot from the Pacific Ocean high area. It was central on the 4th over the north Pacific coast and passed thence eastward to the northern Plains States by the 6th and thence across the Lake Region to the Atlantic coast districts by the 9th. In connection with this, high frosts occurred in Idaho and the North Pacific States all of which were covered by the necessary warnings.

After the passage of this high-pressure area a low center appeared over Nevada on the evening of the 4th and passed slowly eastward to the Texas Panhandle by the 7th; recurving, it passed thence northward to western Ontario, where it seemingly joined with another low area that was over Alberta on the evening of the 7th. In this position it remained practically stationary for about 24 hours while in its trough a secondary developed over northern Lake Michigan. The latter moved eastward out the St. Lawrence Valley. Showers and thunderstorms were quite general over the southern Rocky Mountain region, the Plains States, and thence eastward.

A high-pressure area showed on the south Pacific coast on the 7th and passed northward to eastern Washington by the 9th. It moved to the northern Rocky Mountain region, where it persisted until the 11th, when it was reinforced by a high area from Saskatchewan. This high passed slowly eastward to the Lake Region by the 14th, and during the following 24 hours seemed to divide, one portion passing eastward over the Atlantic, while the other settled southward and southwestward to the West Gulf States by the evening of the 16th.

On the morning of the 13th there were indications of a disturbance over the eastern Bahamas, pressure at Turks Island having fallen 0.14 inch in 24 hours to a reading of 29.94 inches. During the next day a further fall of 0.15 inch took place. Pressure remained practically stationary during the next two days at Turks Island. On the morning of the 16th, however, the wind at Turks Island had backed to west from northeast and during the subsequent 24 hours pressure rose 0.11 inch, while at Bermuda a fall of 0.41 inch was reported. The lowest pressure reported at Bermuda was 29.52 on the evening of the 17th. The storm evidently passed near Bermuda on a northerly course, being in all likelihood the same storm that showed off the Nova Scotia coast on the 19th. Advices were issued to Atlantic coast ports on the 14th and again on the 17th, to the effect that the storm would pass northward off the coast.

Another high-pressure area appeared off the middle Pacific coast on the 13th and passed northward up the coast and on the 15th a high center was over Alberta. During the succeeding two days it progressed to the Upper Lake Region and during the next three days passed to Florida, where it remained until the 21st. Frost warnings were issued on the 12th and 13th for the Ohio Valley and on the 14th for portions of the Middle Atlantic States and frosts occurred generally as indicated in the warning advices.

A low-pressure area passed rapidly from western Ontario on the 19th to the Canadian Maritime Provinces on the 20th, attended by little, if any, precipitation.

The high area following first made its appearance over Alberta on the 19th and passed eastward to the north Atlantic coast with greatly increased intensity by the 22d. It then settled slowly southward over the south Atlantic States, where it persisted until the 23d.

A low-pressure area that developed over the southern Rocky Mountain region passed slowly northward during the 22d and 23d to the northern Plains States, where it lost its identity. Showers occurred over the Plains and west Gulf States.

On the 21st frosts occurred in Washington and Oregon, warnings having been previously issued.

Another low appeared over Nevada on the 23d, and after passing southeastward to the Mexican border ad-

vanced north-northeastward, seemingly joining a storm that was over Alberta on the 26th. The weather chart showed a single center over western Ontario on the 28th, which by the following morning was over eastern Ontario and pressure had fallen over Atlantic coast districts. Barometric pressure remained much below normal over the latter districts until the end of the month. This disturbance caused showers over much of the country from the Plains and west Gulf States eastward to the Atlantic coast. On the 28th warnings of high winds were issued for Lake Superior and winds of gale force occurred during the succeeding 24 hours.

A high-pressure area from the north Pacific coast advanced slowly eastward, and at the end of the month was over Manitoba.

Following the passage of this high through the north Pacific States and northern Rocky Mountain region, pressure became low over the latter district, and at the end of the month a low center was over northwestern Colorado with a pressure reading of 29.24 inches at its center.

On the 29th orchardists in the Portland, Oreg., forecast district were advised that "unusually low temperatures will prevail in the early morning," and this warning was repeated on the 30th. Low temperatures occurred in eastern Washington, eastern Oregon, and southwestern Idaho on the 30th, and on May 1 over eastern Washington, eastern Oregon, and Idaho.

RESUMPTION OF THE WEEKLY FORECAST.

The following announcement was published in the National Weather and Crop Bulletin of April 12:

The outbreak of European hostilities cut off the receipt by the Weather Bureau of many important meteorological observations from northern Europe and other foreign points and on this account the weekly forecasts were suspended in October, 1914. However, in recognition of the great importance to agriculture and related activities of general information concerning forthcoming weather conditions, based on legitimate and reliable meteorological observations, the Weather Bureau is led to resume these forecasts, which will be based on such Northern Hemisphere reports as remain available, for publication in the National Weather and Crop Bulletin and elsewhere. In resuming this work the United States has been divided into nine relatively large districts, for which the weekly forecasts will be issued and the boundaries and extent of which are indicated on the map below. (See fig. 1.)

In addition to the distribution of this information in the bulletin and through the medium of the daily press, forecasts for particular sections will be sent to section centers for distribution through the medium of the local publications of the station and the weekly press.

The following forecast, issued for the week beginning Wednesday, April 14, 1915, indicates the character and scope of these forecasts:

North Atlantic States.—Generally fair weather will continue until the 18th to 20th, when the weather will become unsettled, with probably local showers. The temperature will be low during the 14th to 16th, followed by a marked change to higher temperatures the latter half of the week.

Middle Atlantic States.—The weather will be fair until near the close of the week, when there will be a short period of unsettled weather and showers. The first half of the week will be cool with probably frosts; the latter half of the week will be much warmer.

South Atlantic and East Gulf States.—The week will be one of generally fair weather, with temperature near the seasonal average.

West Gulf States.—Except for local showers and thunderstorms between the 16th and 18th, the week will be one of generally fair weather, with temperatures averaging above the seasonal normal.

Ohio Valley and Tennessee.—Fair weather will prevail until the 17th–19th, when there will be local showers and thunderstorms, followed by a return of fair weather on the 20th. Temperature will rise decidedly the first half of the week and will remain relatively high thereafter until the close of the week.

Region of the Great Lakes.—Fair weather will prevail during the next three or four days; the latter half of the week will be unsettled, with local rains. The temperature will rise decidedly from the 14th to 16th and remain above the seasonal average the latter half of the week.

Plains States and Upper Mississippi Valley.—Generally fair weather, with temperatures above the seasonal average, will prevail until the 17th–18th, when there will be local showers and thunderstorms, to be followed by fair and cooler weather the latter part of the week.

Rocky Mountain and Plateau Regions.—Local showers the beginning of the week will be followed by several days of fair weather, with temperatures near or slightly below the seasonal average.

Pacific States.—The week will be one of generally fair weather, with temperatures below the normal. Showers are probable the latter half of the week in Washington and Oregon.

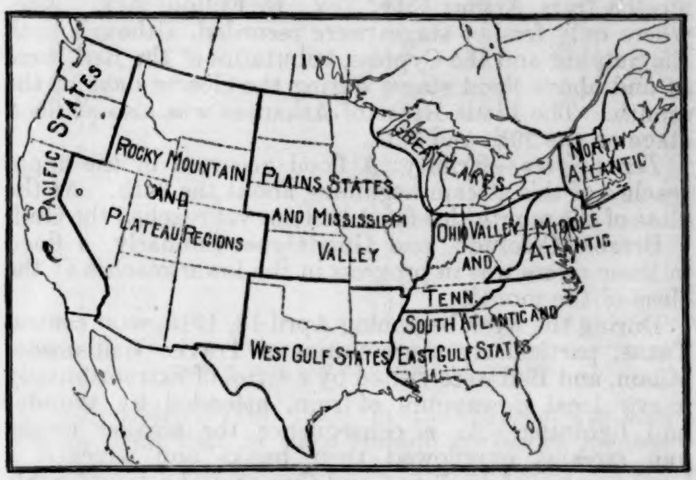

FIG. 1.—Districts for which weekly forecasts are published by the U. S. Weather Bureau.

NORTHERN HEMISPHERE PRESSURE.

Alaska.—Pressure was generally low for the month, particularly so over the northern portion, where it averaged 0.20 inch or more. Lows occurred about April 2, 6, 11–12, 13–14, 16, 21, 23, and 25–26; and highs about April 9, 19, and on the last of the month.

Honolulu.—Pressure averaged below normal, there being only three days during the month when it was above. Lows occurred on the 1st, 4th, 9th, 19th–22d, and 28th–29th. No highs of importance occurred.

Azores.—Pressure was decidedly above the average for the season, continuously high pressure prevailing up to the 25th, followed by pressure decidedly below normal during the remainder of the month. Although the pressure was decidedly above normal for the first 24 days of the month, no important crests occurred. The lowest pressure occurred during the 28th–29th.

SECTION IV.—RIVERS AND FLOODS.

RIVERS AND FLOODS, APRIL, 1915.

By ALFRED J. HENRY, Professor in charge of River and Flood Division.

[Dated: Washington, D. C., May 27, 1915.]

The only floods of consequence during the month were in the rivers of the Southwest, viz, those of Texas, including the Pecos and Rio Grande, the Red, and the Arkansas. All the floods were due to general rains over the respective watersheds.

There were two high water periods in the Red River, the first continuing from the 15th to the 18th, but the second and greatest from the 27th to the end of the month. The river passed above flood stage along the stretch from Arthur City, Tex., to Fulton, Ark. Elsewhere only freshet stages were recorded, although both the Sulphur and the Cypress, tributaries of the Red, were at and above flood stages during the closing days of the month. The Little River of Arkansas was also at flood stage on the 29th and 30th.

Texas rivers.—Trinity: A flood occurred in the upper reaches of this stream beginning about the 24th. At the close of the month this flood had not yet reached the Gulf.

Brazos, Colorado, and Guadalupe: Similarly, a flood in these rivers was in progress in the lower reaches at the close of the month.

During the week beginning April 18, 1915, west central Texas, particularly the counties of Travis, Williamson, Milam, and Bell were visited by a series of extraordinarily heavy local downpours of rain, attended by thunder and lightning. As a consequence the smaller creeks and streams overflowed their banks and wrecked a large number of dwellings, and thus caused a considerable loss of life. On May 3 it was estimated that 40 persons had lost their lives as a result of the floods. Twenty-one bodies were recovered at Austin, Tex., where the rainfall was 10 inches in 24 hours. The Colorado River at Austin, however, lacked half a foot of reaching the flood stage. The large loss of life in most cases occurred along the smaller streams. For additional information about floods in Texas see the article by B. Bunnemeyer below.

Rio Grande: Frequent rains in New Mexico and southwest Texas, particularly in the watershed of the Pecos River, from the 14th to the 18th, caused a moderate flood in that stream, which crested in a stage of 19.5 feet at Pecos, Tex., on the 21st. Relatively high stages were also recorded in the Rio Grande and in general the streams of eastern New Mexico, including the Canadian, were at freshet stages during the latter part of the month.

Heavy rains also affected the Arkansas in its course through Kansas, Oklahoma, and Arkansas, but the floods were not destructive in any case.

Damages.—In the vicinity of Carlsbad, N. Mex., the damage to canal headwork on the Carlsbad project, was approximately $5,000 and miscellaneous losses about $1,000. In the extreme southern part of the valley, in the vicinity of Barstow and Pecos, Tex., the damage to canals and the irrigation flume across the river is estimated at $4,000, and to alfalfa in fields $3,000. The prospective losses in alfalfa, cotton, and feed from water shortage due to damage to canals and flume, will probably amount to $25,000 or $30,000. In this vicinity property valued at $9,000 was saved by the warnings sent from the Denver office of the Bureau.

Hydrographs for typical points on several principal rivers are shown on Chart I. The stations selected for charting are Keokuk, St. Louis, Memphis, Vicksburg, and New Orleans, on the Mississippi; Cincinnati and Cairo, on the Ohio; Nashville, on the Cumberland; Johnsonville, on the Tennessee; Kansas City, on the Missouri; Little Rock, on the Arkansas; and Shreveport, on the Red.

FLOODS IN TEXAS DURING APRIL AND MAY, 1915.

By B. BUNNEMEYER, Section Director.

[Dated Weather Bureau, Houston, Tex., May 30, 1915.]

The floods that occurred in Texas during the last decade of April, 1915, and extended well into May, while far from approaching the severity of the record-breaking floods of December, 1913, are memorable from the fact that they caused a loss of 40 lives and an indeterminable but immense damage to crops, which had to be replanted not only in the flooded area but also in sections where the soil had been washed by heavy rains. Incomplete returns give an estimated damage of $2,354,125, exclusive of losses sustained by railroad, telegraph and telephone companies, classified as follows:

TABLE 1.—*Losses by the Texas floods of April–May, 1915.*

Losses in—	Watersheds.				
	Colorado.	Brazos.	Trinity.	Guadalupe.	Total.
County bridges, roads, buildings, etc.	$650,750	$159,900	$15,400	$500	$826,550
Crops	5,250	1,324,000	6,000	6,500	1,341,750
Live stock		68,825			68,825
Suspension of business		102,500	10,000	4,500	117,000
Total	656,000	1,655,225	31,400	11,500	2,354,125

The total damage, and especially the damage to crops, is much greater than the estimate here given on account of the small number of returns received and of the fact that in many instances no monetary value was affixed to the losses sustained.

Nearly all the deaths occurred in the creeks that were rapidly converted into raging torrents by the heavy rains and caught the people unawares. Of the 40 deaths perhaps 8 could have been prevented by the exercise of a little caution.

Considerably over one-half of the total damage reported was due to loss of crops in the field; over one-third consisted of damage to buildings, bridges, and roads, mostly in the city of Austin; and the remainder, less than one-twelfth, represents losses by suspension of business and drowning of live stock. Railroads suffered considerably from washouts and interruption to traffic.

From April 14 to 20, 1915, a series of local showers occurred over the Guadalupe, Colorado, Brazos, and Trinity watersheds, which became sufficiently cumulative to justify the issuance of advisory warnings on April 20

for the Guadalupe and lower Colorado. Most of this rainfall soaked into the ground and no dangerous rises occurred. On April 21 the precipitation was too light to affect the streams; but on the 22d unusually heavy showers set in, which were reported on the morning of April 23 and resulted in an immediate issuance of flood warnings for the Guadalupe, middle and lower Colorado, middle and lower Brazos, and upper Trinity. These warnings were followed up from time to time by advices and reports of the progress of the floods.

Colorado River.—The Colorado flood began during the night of April 22–23. A heavy rain set in at Austin about 7:45 p. m., April 22, and by midnight as much as 8 inches of water had fallen. The rain converted Waller and Shoal Creeks into raging torrents, and the flood damage and loss of life at Austin are almost entirely due to the overflows of these creeks. Shoal Creek empties into the Colorado below the dam and about one-half mile above Congress Avenue wagon bridge, on which the river gage is located, and Waller Creek about one-half mile below that bridge. The river gage therefore showed only the flood waters coming in from Shoal Creek. The channels of these creeks are naturally narrow, and on Waller Creek houses had been built to the edge of the banks. The width of either stream at the time of the crest did not exceed one-fourth of a mile, and possibly as much as 6 square miles of territory were submerged. The depth of the water in the middle of the channels was probably as much as 30 or 40 feet. The damage occurred between 11 p. m., April 22, and 1 a. m., April 23, and by sunrise the creeks had practically run down.

The daily rainfalls and river stages resulting are presented in Tables 2 and 3.

TABLE 2.—*Rainfalls over the Colorado watershed, April 14–26, 1915.*

Stations.	Total, Apr. 14–20.	Daily rainfalls, Apr. 21–26, 1915.						
		21	22	23	24	25	26	Total.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
Lamesa	1.56	0.24	....	0.90	2.30	....	....	3.44
Midland	1.71	....	0.82	....	....	1.03	....	1.85
Garden City	1.11	....	1.05	....	0.09	0.66	....	1.80
Snyder	3.07	....	0.12	0.69	....	2.00	....	2.81
Big Spring	1.61	0.15	0.75	....	0.16	1.29	....	2.35
Colorado	1.66	....	....	1.01	....	....	....	1.01
San Angelo	1.25	....	2.63	1.12	....	0.80	....	4.55
Knickerbocker	1.15	....	2.73	T.	T.	0.80	....	3.53
Ballinger	1.20	....	1.10	1.20	T.	1.00	....	3.30
Coleman	0.68	0.85	1.88	....	T.	1.50	....	4.23
Brownwood	0.12	....	0.40	1.20	....	0.50	0.25	2.35
San Saba	1.63	....	1.61	0.64	....	1.28	....	3.53
Junction	0.95	....	1.38	....	....	1.10	....	2.48
Llano	1.89	0.80	0.03	0.70	....	0.78	0.33	2.64
Marble Falls	2.07	T.	T.	1.60	....	1.00	1.60	4.20
Fredericksburg	2.01	....	0.61	....	T.	1.78	....	2.39
Duval	2.03	....	0.52	6.58	0.20	5.89	....	13.19
Austin	2.78	....	....	10.00	0.29	3.05	3.00	16.34
La Grange	3.35	....	0.02	3.09	0.04	1.53	0.30	4.98
Columbus	1.80	....	....	1.78	2.10	0.32	0.20	4.40
Bay City	0.00	....	....	....	3.76	0.70	T.	4.46
Pierce	0.36	....	....	2.53	1.76	2.02	0.03	6.34
Total	33.99	2.04	15.65	33.04	10.70	29.03	5.71	96.17
General means.	1.54	0.09	0.71	1.50	0.49	1.32	0.26	4.37

T=Trace of precipitation, i. e., less than 0.01 inch.

The destruction of buildings, bridges, culverts, and damage accomplished to streets by the flood waters is estimated at about $650,000, and 32 persons are known to have drowned. One of the persons drowned lost his life on Bee Creek, which empties into the Colorado just above the dam. A second flood occurred at Austin in the afternoon of April 25, with gage readings 17.5 feet at 3 p. m. and 17.8 feet at 7 a. m. next morning. These two floods had a fall of 8 feet between their crests at Lagrange, but at Columbus the fall was not pronounced. At this last-named station the crest passed at 4 p. m. April 28, with gage reading 36.3 feet. This is 7.8 feet lower than recorded during the flood of December, 1913. The width of the flooded area below Columbus was from one-half to two miles.

TABLE 3.—*River stages of the Colorado River during flood, April 15–May 10, 1915.*

[8 a. m., 75th meridian time or 6 a. m., 105th meridian time.]

	Ballinger.	Marble Falls.	Austin.	Columbus.
Flood stage	21 feet.	36 feet.	18 feet.	24 feet.
	Feet.	*Feet.*	*Feet.*	*Feet.*
Apr. 15	1.0	2.7	1.0	8.5
16	1.0	2.6	1.3	8.5
17	1.0	2.6	2.7	7.9
18	1.0	3.0	4.1	7.8
19	1.0	3.2	3.9	7.5
20	4.0	3.6	3.9	18.1
21	2.0	5.4	3.8	19.2
22	4.0	4.9	1.9	14.8
23	7.0	6.2	6.8	16.9
24	2.0	10.2	5.0	**33.8**
25	7.6	10.8	10.5	**35.0**
26, 8 a. m.	4.0	13.4	17.8	**34.8**
26, 5 p. m.	16.0	....	....	....
27	11.0	10.0	12.0	**35.8**
28, 8 a. m.	12.0	12.9	11.0	**36.2**
28, 4 p. m.	....	....	....	**36.3**
29	3.0	12.0	12.0	**35.4**
30	4.0	9.0	10.5	**32.9**
May 1	2.0	8.0	8.4	**30.7**
2	2.0	5.6	6.5	**26.0**
3	2.0	5.0	5.4	22.2
4	2.0	5.2	6.0	19.4
5	4.0	5.6	5.0	18.2
6	3.0	5.4	4.8	18.0
7	3.0	5.2	4.8	16.5
8	3.0	5.0	4.5	16.2
9	2.0	4.6	4.2	15.5
10	2.0	4.5	4.0	15.0

Stages at or above flood stage are in black-face type.

Brazos River.—The flood in the Brazos was much severer than that in the Colorado so far as monetary value of the damage sustained is concerned; but there were only five deaths by drowning and these appear to have been accidental or the result of foolhardiness. In the upper portion of the stream from Brazos in Palo Pinto County to near Valley Junction in Robertson County there were two distinct but mild floods, which resulted in a comparatively slight loss of crops only. At Valley Junction, however, the flood was severe, due to an immense volume of water coming in from the Little River. On the morning of April 23 unusually heavy rains were reported from the Little River watershed, with 8.29 inches at Taylor and 7.30 inches at Cameron. The river observer at Valley Junction reported a stage of 26 feet at 7 a. m. of the 23d, and on the following morning he reported the gage under water and inaccessible. Later he found that the height of the water on April 24 corresponded to a gage reading of 50 feet. This is the highest observed at Valley Junction and is 5 feet less than the crest of the record flood of December, 1913. The crest of the flood was at Washington 7 p. m. April 27, with a stage of 52.9 feet. The stream remained stationary for 12 hours and then began to fall slowly. It reached Hempstead on April 29, with a stage of 46.5 feet; and Rosenberg at 11 p. m. May 1, with a stage of 46.4 feet. No records were obtained from either Washington or Rosenberg in December, 1913, but at Hempstead the stream was 6.3 feet higher in December, 1913, than in the present flood. The width of the stream ranged from about 1½ to 5 miles at and below Valley Junction, and a few of the smaller towns were partly under water. (See Tables 4 and 5.)

TABLE 4.—*Rainfalls over the Brazos watershed, Texas, April 14–26, 1915.*

Stations.	Total, Apr. 14–20.	Rainfall Apr. 21–26, 1915.						
		21	22	23	24	25	26	Total.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
Plainview	2.76	0.16			0.18	2.10		2.44
Mount Blanco	1.15				T.	2.00		2.00
Lubbock	2.51	0.60	T.		0.31	1.51		2.42
Tahoka	1.32	T.			1.79	2.98		4.77
Post	1.94				0.42	2.03		2.45
Spur	2.22			0.08		2.00		2.08
Aspermont	2.64		0.48		1.94			2.42
Haskell	1.87		1.18	0.40		1.31		2.89
Goree	1.01	0.78	0.21		1.61			2.60
Seymour	0.94		1.78	0.16	1.00	1.01		3.95
Claytonville	1.12		1.28	T.	0.04	1.10		2.42
Abilene	2.90	0.64	1.33		0.06	1.49		3.52
Hamlin	2.23			0.50		1.30		1.80
Stamford	1.71	T.	2.10			1.20		3.30
Albany	1.25		1.90			1.10		3.00
Graham	2.04	0.57	1.20		2.36	0.92		5.05
Putnam	0.20		2.45		1.80			4.25
Brazos	1.03		0.38	3.64		0.21	1.74	5.97
Eastland	0.66		0.02	1.63	T.	2.04	0.04	3.73
Panter	1.38	T.	1.04		0.46		2.45	3.95
Dublin	1.39		0.30	1.29		0.40	0.85	2.84
Cleburne	0.83		1.43	0.81		0.81	0.27	3.32
Hico	1.17		1.56		0.14	1.43		3.13
Kopperl	1.10		0.70	2.80		0.44	0.60	4.54
Clifton	1.00	T.	2.01	1.20	0.16	0.54	0.01	3.92
Hillsboro	0.92		0.15	2.45	0.28	0.80	0.76	4.44
Lampasas	1.89		0.06	2.51		0.31	1.00	3.88
Gatesville	0.80		1.30	1.70	0.10	0.35		3.45
McGregor	1.80		3.20		0.25	0.75		4.20
Waco	1.17	T.	T.	2.00	0.12	0.83	0.94	3.89
Hewitt	2.04	0.06	1.48	1.06	0.05	0.64	0.63	3.92
Gorham	2.19	0.34	T.	2.60	0.14	0.50	0.56	4.14
Mexia	0.65	0.06		5.20	0.88	2.03	0.60	8.77
Salado	2.71		1.97	1.32		1.48	1.08	5.85
Temple	1.91			3.30	0.20	0.59	2.53	6.62
Taylor	1.70		8.29	1.50	2.01	1.95		13.75
Georgetown	1.99		0.02	3.05	0.20	0.86	2.74	6.87
Cameron	1.89		7.30	0.22	3.51	1.27		12.30
Valley Junction	1.50	0.50		2.50	1.00	2.00		6.00
College Station	2.75		T.	2.97	0.98	0.42	0.13	4.50
Somerville	1.60		T.	3.00		0.30	T.	3.30
Navasota	1.73			1.20	2.45	1.10	0.14	4.89
Brenham	1.33			1.03	1.70	0.70	0.30	3.73
Hempstead	1.30	0.45		1.05	2.15	0.45	0.10	4.20
Sealy	0.83		0.06	2.27	0.39	0.04	0.02	2.78
Sugarland	1.14				1.62	0.35		1.97
Rosenberg	1.41	T.		0.17	4.35	1.01	0.01	5.54
Brazoria	0.16		0.06	3.48	0.35		0.09	3.98
Total	73.78	4.16	45.24	57.09	35.00	46.65	17.59	205.73
General means	1.54	0.09	0.94	1.19	0.73	0.97	0.37	4.29

T=Trace of precipitation, less than 0.01 inch.

TABLE 5.—*River stages of the Brazos River during flood, April 15–May 10, 1915.*

[8 a. m., seventy-fifth meridian time, or 6 a. m., one hundred and fifth meridian time.]

	Brazos.	Kopperl.	Waco.	Valley Junction.	Washington.	Hemp.	Rosenberg.
Flood stage	12 feet.	21 feet.	22 feet.	40 feet.	45 feet.	40 feet.	39 feet.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Apr. 15	1.7	0.9	5.8	4.3	11.2	4.2	2.8
16	2.2	0.8	6.1	4.2	11.0	3.1	2.6
17	2.2	0.8	6.0	4.0	9.4	2.0	2.3
18	2.1	0.8	5.9	3.8	9.2	2.8	2.0
19	2.1	1.0	5.8	3.8	9.1	2.9	2.0
20	2.0	1.4	7.5	5.0	11.4	2.4	2.1
21	2.0	2.6	8.5	9.5	20.6	6.6	3.8
22	5.0	2.8	7.5	12.4	22.0	12.9	8.3
23	10.0	13.0	20.0	26.0	23.1	13.8	10.1
23			**25.3**				
24	7.5	13.6	21.2	**50.0**	44.0	32.4	16.5
25	7.5	9.5	18.5	**46.0**	**47.1**	36.0	28.7
26	**16.0**	19.0	**21.6**	**44.0**	**50.5**	36.8	31.0
26	**16.4**		**26.0**				
27	**13.0**	20.0	**24.8**	**42.0**	**52.4**	**43.4**	31.5
27, 7 p. m.					**52.9**		
28	**13.6**	18.6	**23.7**	41.0	**52.9**	**46.2**	33.3
29	7.8	16.8	**23.3**	36.0	**52.7**	**46.5**	35.0
30	7.0	8.2	16.2	32.6	**51.9**	**45.6**	**39.5**
May 1		7.0	14.0	26.5	**51.0**	**44.5**	**45.2**
1, 11 p. m.							**46.4**
2		5.8	12.8	18.0	**49.7**	**43.0**	**46.3**
3		6.4	11.5	16.5	**48.3**	**42.2**	**45.8**
4		5.0	10.9	15.0	**46.3**	**40.6**	**44.9**
5		6.2	12.9	13.5	43.3	38.8	**43.8**
6		6.0	12.0	12.0	40.4	36.0	**42.2**
7		5.6	11.3	12.0	36.3	32.4	**39.8**
8		5.4	10.5	12.9	33.1	29.2	36.9
9		5.4	9.7	9.5	29.9	28.4	32.0
10		6.0	13.2	8.0	27.1	24.6	23.5

Stages at or above flood stage are in black-faced type.

Lowlands were deserted before the water came and stock and property moved out as far as possible. All crops submerged proved a total loss and some farms were completely ruined. In some places sand banks 3 to 5 feet high washed up, and in other places big holes and gullies were left. The crest of the flood reached the Gulf on May 6.

TABLE 6.—*Rainfalls over the Trinity watershed, Texas, April 14–26, 1915.*

Stations.	Total Apr. 14–20.	Rainfall, Apr. 21–26, 1915.						
		21	22	23	24	25	26	Total.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
Bowie	1.17		1.17	2.89		3.54		7.60
Antelope	1.13		0.63		0.12	1.70	0.09	2.54
Gainesville	1.22	0.55	1.50	0.49		0.31	0.73	3.58
Bridgeport	0.63	T.	0.32	2.10	T.	0.97	2.00	5.39
Weatherford	0.77		0.28	1.02		0.90	1.55	3.75
Grapevine	0.73		2.24	0.20	0.20		1.52	4.16
Fort Worth	0.55		1.32	1.26	0.30	0.94		3.82
Denton	0.41	0.12	1.32	0.77	T.	0.24	1.28	3.73
McKinney	0.16	0.24	2.14	1.95	0.40	0.10	1.67	6.50
Dallas	0.15	T.	1.87	1.13	T.	0.36		3.36
Kaufman	0.26	T.	0.93	2.60	0.70	0.26	0.88	5.37
Waxahachie	0.69			3.60	0.54	0.28	0.72	5.14
Trinidad	0.23			3.84	1.69	0.75	1.46	7.74
Corsicana	0.18			3.15	0.60	0.92	2.20	6.87
Palestine	0.58	T.	0.10	2.79	1.75	0.53	1.26	6.43
Long Lake	0.80			0.90	1.96	1.88	0.60	5.34
Jewett	3.25		1.05		1.10	3.00	0.35	5.50
Crockett	1.64		0.10	1.44	2.70	0.26	0.25	4.75
Riverside	2.00	0.18		0.25	0.97	0.37	T.	1.77
Huntsville	2.92	0.20		0.40	0.79	0.16	0.09	1.64
Liberty	2.25	T.		0.07	0.60	T.	0.7	0.74
Total	21.72	1.29	14.97	30.85	14.42	17.47	16.72	95.72
General means	1.03	0.06	0.71	1.47	0.69	0.83	0.80	4.56

T.=Trace of precipitation; less than 0.01 inch.

TABLE 7.—*River stages of the Trinity River during flood of April 15–May 20, 1915.*

[8 a. m., 75th meridian time; 6 a. m., 105th meridian time.]

	Bridgeport,	Fort Worth,	Dallas,	Longlake,	Riverside,	Liberty.
Flood stage	20 feet.	20 feet.	25 feet.	40 feet.	40 feet.	25 feet.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Apr. 15	1.5	5.0	9.3	20.5	6.8	11.3
16	1.5	4.6	8.5	20.9	7.4	10.0
17	1.4	4.2	7.9	18.5	9.8	9.0
18	1.4	4.0	7.5	16.5	10.5	10.5
19	3.9	4.0	7.3	14.0	10.2	12.0
20	5.8	4.4	7.3	12.8	16.0	13.0
21	4.2	4.5	8.3	11.5	16.5	13.5
22	1.8	5.7	10.1	9.4	14.3	18.2
23	**25.0**	14.0	21.8	10.5	12.4	20.9
24	**20.6**	6.4	**29.9**	29.7	16.3	21.3
25	16.8	8.1	**32.4**	36.0	22.0	21.0
26	**25.3**	**29.4**	**33.3**	39.0	29.8	21.9
26, 6 p. m.		**32.4**				
27	**22.7**	**26.1**	**35.5**	**42.0**	32.4	23.0
28	**22.5**	**29.8**	**35.7**	**44.8**	32.0	24.0
29	18.9	**29.4**	**36.2**	**46.4**	31.0	24.5
29, 7.30 p. m.			**36.7**			
30	9.5	**22.0**	**36.5**	**46.1**	30.4	**25.0**
May 1	5.5	**22.6**	**35.5**	**45.5**	28.3	**25.4**
2	4.6	**20.8**	**33.3**	**44.8**	28.3	**25.7**
3	3.0	15.0	**32.0**	**43.9**	29.0	**26.0**
4	3.0	12.4	**31.1**	**43.5**	31.6	**26.2**
5	2.8	7.8	**29.4**	**43.0**	34.0	**26.3**
6	2.8	6.4	22.0	**43.0**	36.1	**26.4**
7	5.2	7.3	16.8	**43.3**	37.8	**26.4**
8	4.5	5.9	23.0	**43.0**	38.7	**26.4**
9	4.0	5.4	24.9	**43.2**	39.1	**26.5**
10	7.7	7.9	19.7	**43.0**	38.9	**26.6**
11	6.4	6.6	15.4	**42.8**	38.1	**26.7**
12	3.5	6.1	16.1	**42.4**	37.5	**26.8**
13	3.2	5.8	16.0	**42.0**	37.1	**26.9**
14	3.0	6.4	15.4	**41.6**	36.7	**27.0**
15	3.0	6.0	14.6	**41.1**	36.2	**27.1**
16	2.8	5.6	12.5	**40.5**	36.0	**27.2**
17	2.5	5.0	10.9	**40.0**	35.7	**27.3**
18	2.5	4.8	9.9	38.8	35.3	**27.3**
19	2.2	4.6	12.7	36.5	34.5	**27.3**
20	2.0	9.8	11.3	30.5	33.2	**27.3**

Stages at or above flood stage are in black-face type.

Trinity River.—The Trinity River flood was comparatively mild, and the resulting losses small when compared with those sustained in the Brazos and Colorado overflows. The rainfall is presented in detail by Table 6, below. The stream was strongly fluctuating above Dallas from April 22 to 27, but at Dallas there was a continuous rise after the flood stage was reached on the 23d. The crest occurred at 7.30 p. m. April 29, with stage 36.7 feet, and the water continued out of banks until the night of May 5-6. At Long Lake, which is near Palestine and 109 miles below Dallas, the crest occurred also on April 29, due to flood waters coming in from Cedar and Pecan Creeks, which drain a considerable territory above Long Lake. The subsidence of the flood at Long Lake was slow and the water did not get within banks again until May 17. At Liberty, the lowest river station on the Trinity, flood stage was reached on April 30.

The stream rose extremely slowly until May 17, as shown by Table 7, when it attained a stage of 27.3 feet, remained stationary during the next five days, and then began to recede as slowly as it had risen. At Dallas one person accidentally fell into the stream and was drowned. The stream flows through much woodland after leaving Dallas and comparatively little territory is under cultivation, so that the crop damage could not have been excessive. No animals were reported lost, although stock, and especially hogs, are permitted to run at large in the woods.

Guadalupe River.—On the Guadalupe River the flood was of comparatively short duration at Gonzales. On April 21 the river got bank full at that place and then fell rapidly, but, as shown by Table 9, it soon rose again on the 24th, and by 5.30 a. m., April 25, attained a stage of 30 feet, its highest reported stage. The rainfall is shown in Table 8. At Victoria, which is below Gonzales, the stream rose steadily from April 21 to April 28, when the crest passed with a stage of 24.5 feet. The flood subsided by May 5. The flats at the edge of Victoria were under several feet of water at the height of the flood.

TABLE 8.—*Rainfall on the Guadalupe watershed April 14-26, 1915.*

Stations.	Total Apr. 14-20.	Rainfall Apr. 21-26, 1915.						
		21	22	23	24	25	26	Total.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
Kerrville	1.66	....	0.08	0.74	0.00	0.75	1.03	2.60
New Braunfels	5.41	....	....	2.30	0.52	0.57	0.22	3.61
Luling	3.93	....	....	1.58	0.65	0.76	0.10	3.09
Blanco	1.68	....	....	1.90	0.47	0.26	1.33	3.96
San Marcos	1.00	....	....	1.50	0.49	0.71	0.61	3.31
Flatonia	2.44	....	0.10	2.64	3.95	0.20	0.20	7.09
Gonzales	2.67	....	....	2.07	0.41	0.47	0.08	3.03
Cuero	1.27	....	....	2.98	0.57	0.44	0.15	4.14
Victoria	0.05	....	....	1.96	1.29	....	....	3.25
Austwell	0.00	....	....	0.87	1.43	....	....	2.30
Total	20.11	0.00	0.18	18.54	9.78	4.16	3.72	36.38
General means	2.01	0.00	0.02	1.85	0.98	0.42	0.37	3.64

TABLE 9.—*Stages of the Guadalupe River, April 15 to May 10, 1915.*

[8 a. m., 75th meridian time; 6 a. m., 105th meridian time.]

	Gonzales.	Victoria.		Gonzales.	Victoria.
Flood stage	22 feet.	16 feet.	Flood stage	22 feet.	16 feet.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Apr. 15	2.5	3.9	Apr. 28	**27.0**	**24.5**
16	2.5	2.8	29	**24.3**	**24.3**
17	2.3	2.8	30	19.0	**24.0**
18	2.3	2.9	May 1	11.5	**23.8**
19	8.3	2.9	2	9.9	**22.9**
20	20.8	3.3	3	9.0	**22.4**
21	**22.0**	14.4	4	8.2	**16.8**
22	17.5	**19.2**	5	7.7	15.4
23	9.6	**21.4**	6	10.0	14.4
24	21.8	**22.6**	7	10.7	13.9
25	**29.9**	**23.0**	8	9.0	13.3
25 5.30 a. m.	**30.0**	....	9	7.3	12.6
26	**29.0**	**23.0**	10	6.7	10.3
27	**28.2**	**23.9**			

Stages at or above flood stage are in black face type.

It is regretted that the returns received were too meager to give an adequate idea of the losses sustained. Replanting of crops was begun immediately upon the subsidence of the floods and, with favorable weather conditions, the outlook is not discouraging.

MEAN LAKE LEVELS DURING APRIL, 1915.

By UNITED STATES LAKE SURVEY.

[Dated: Detroit, Mich., May 6, 1915.]

The following data are reported in the "Notice to Mariners" of the above date:

Data.	Lakes.			
	Superior.	Michigan and Huron.	Erie.	Ontario.
Mean level during April, 1915:	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Above mean sea level at New York	601.34	579.48	571.45	245.04
Above or below—				
Mean stage of March, 1915	−0.16	−0.09	+0.08	−0.23
Mean stage of April, 1914	−0.50	−0.60	−0.73	−1.71
Average stage for April, last 10 years	−0.30	−0.91	−0.97	−1.44
Highest recorded April stage	−1.35	−3.75	−2.73	−3.39
Lowest recorded April stage	+0.80	+0.26	+0.19	+0.20
Probable change during May, 1915	+0.3	+0.3	+0.4	+0.4

SECTION V.—SEISMOLOGY.

SEISMOLOGICAL REPORTS FOR MARCH, 1915.

W. J. HUMPHREYS, Professor in charge of Seismological Investigations.

[Dated: Weather Bureau, Washington, D. C., June 1, 1915.]

TABLE 1.—*Noninstrumental earthquake reports, April, 1915.*

Day.	Approximate time Greenwich Civil.	Station.	Approximate latitude.	Approximate longitude.	Intensity Rossi-Forel.	Number of shocks.	Duration.	Sounds.	Remarks.	Observer.
		CALIFORNIA.								
	H. m.		° ′	° ′			M. s.			
1	13 25	Julian	33 05	116 37	2	1	6	Rumbling		J. H. L. Vogt.
	13 25	Mesa Grande	33 11	116 42	2	1	4	Rumbling		Edward H. Davis.
3	20 00	El Cajon	32 48	116 58	3	1	3	Rumbling	Windows rattled	H. H. Kessler.
5	21 45	Bridgeport	38 17	119 16	3	1	3	Rumbling		A. F. Scott.
	21 45	Coleville	38 36	119 32	4	1		Rattling		F. W. Chichester.
	21 45	Coulterville	37 42	120 13	3	1		Rumbling	Windows rattled	W. H. Dudley.
5	23 11	Bridgeport	38 17	119 16	4	1	5	Rumbling	Shook buildings	A. F. Scott.
	23 11	Camino	38 46	120 41	2	3				U. S. Forest Service.
	23 11	Coleville	38 36	119 32	5	2		Rumbling	Shook buildings	F. W. Chichester.
	23 11	Coulterville	37 42	120 13	3	2		Rumbling	Windows rattled	W. H. Dudley.
	23 11	Markleeville	38 42	119 46	2	2		Faint		Mrs. Mary Thornburg.
	23 11	Northfork	37 08	119 33	2	1	1			U. S. Forest Service.
	23 11	Sonora	37 59	120 24	3	1				Chas. P. Jones.
	23 11	Towle	39 14	120 48	3	1	6		Windows rattled	F. P. Harmon.
6	16 27	Coyote	37 14	121 44	3	3	4		Windows rattled	Bay Cities Water Co.
	16 27	Spreckels	36 35	121 38	4	1	5			J. K. Scott.
	16 27	Watsonville	36 55	121 46	5	1	15	Rumbling		Spreckels Sugar Co.
13	20 09	San Diego	32 43	117 10	2	1	3			U. S. Weather Bureau.
17	6 20	Markleeville	38 42	119 46	2	4	20	Rumbling		Mrs. Mary Thornburg.
	6 20	Sonora	37 59	120 24	4	1		Faint		Chas. P. Jones.
21	5 30	Cahuilla	33 32	116 43	3	1	2	Rumbling		Dr. Wm. L. Shawk.
21	10 00	Lonoak	36 20	120 00	2	1				M. L. Griffin.
	10 00	San Luis Obispo	35 18	120 39	3	1	3	Rumbling		U. S. Weather Bureau.
28	3 10	Brawley	32 59	115 40	4	1	2	Rumbling		M. D. Witter.
30	5 30	Brawley	32 59	115 40	2	1				M. D. Witter.
30	8 20	Brawley	32 59	115 40	5	1	3	Rumbling	People awakened	M. D. Witter.
30	13 45	Brawley	32 59	115 40	3	1			Several lighter shocks during day.	M. D. Witter.
		ILLINOIS.								
15	13 20	Olney	38 45	88 07	2	1		Rumbling		J. T. Ratcliffe.
		MISSOURI.								
28	23 40	New Madrid	36 35	89 32	4	1		Rumbling		Miss Josie Smith.
		NEVADA.								
5	21 45	Smith	38 43	119 21	2	1			See California	C. M. Carter.
5	23 11	Gardnerville	38 55	119 43	5	2	2		See California	U. S. Forest Service.
	23 11	Smith	38 43	119 21	4	1		Rumbling		C. M. Carter.
	23 11	Yerington	38 58	119 11	4	1	10			A. E. Ricksecker.
		TENNESSEE.								
28	23 40	Tiptonville	36 23	89 30	5	1	8	Rumbling	Many frightened; see Missouri	I. F. Lemonds.
		UTAH.								
26	5 30	Emery	38 54	111 17	2	1		Rumbling		H. C. Wickman.
		WASHINGTON.								
22	18 35	Sumner	47 12	122 13	3	1	3	Rumbling	Felt at several places along head of Puget Sound.	H. E. Thompson.
	18 35	Tacoma	47 16	122 23	5	1	8	Rumbling		U. S. Weather Bureau.

TABLE 2.—*Instrumental reports, April, 1915.*

Time used: Mean Greenwich, midnight to midnight. Nomenclature: International.

[For significance of symbols see this REVIEW, December, 1914, p. 689.]

Date.	Character.	Phase.	Time.	Period. T	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.

Alaska. Sitka. Magnetic Observatory, U. S. Coast and Geodetic Survey. J. W. Green.

Lat., 57° 03′ 00″ N.; long., 135° 30′ 06″ W. Elevation, 15.2 meters.

Instruments: Two Bosch-Omori, 10 and 12 kilograms.

Instrumental constants: E: V 10, T_0 17.4; N: V 10, T_0 15.6

[No earthquakes recorded during April, 1915.]

Arizona. Tucson. Magnetic Observatory, U. S. Coast and Geodetic Survey. F. P. Ulrich.

Lat., 32° 14′ 48″ N.; long., 110° 50′ 06″ W. Elevation, 769.6 meters.

Instruments: Two Bosch-Omori, 10 and 12 kg.

Instrumental constants: E: V 10, T_0 16; N: V 10, T_0 19.6

Date.	Character.	Phase.	Time.	Period.	A_E	A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Apr. 10		e_E	0 52 18					
		e_N	0 52 37					
		M_E	0 54 28	9	10			
		M_N	0 53 33	8		10		
		F_E	1 00 00					
23		L	15 44 49	4				
		M	15 44 54	5	20	10		
		C	15 47 00	4				
		F	15 55 00	4				

California. Point Loma. Raja Yoga Academy. F. J. Dick.

Lat., 32° 43′ 03″ N.; long., 117° 15′ 10″ W. Elevation, 91.4 meters.

Instrument: West, two-component seismoscope.

Date.	Character.	Phase.	Time.	Period.	A_E	A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Apr. 13	I_4		12 10 —		125	125		Windows rattled.

Colorado. **Denver. Sacred Heart College.** Earthquake Station. A. W. Forstall, S. J.

Lat., 39° 40′ 36″ N.; long., 104° 56′ 54″ W. Elevation, 1,655 meters.

Instrument: Wiechert 80 kg., astatic, horizontal pendulum.

Date.	Character.	Phase.	Time.	Period.	A_E	A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Apr. 15			19 56 00					Activity, especially on E-W, and also later during day.
19		$?_E$	18 26 00					Nothing on N-S.
19		$?_E$	21 02 00					Nothing on N-S.
		F	21 04 00					
20		L_E	17 27 00					
		F	17 29 00					
20		L	19 02 00					On both components. Occurs later during day on N-S.
24		L	18 30 00					Not on N-S.
		F	19 00 00					
24			20 29 00					Nothing on N-S.
		F	20 42 00					

District of Columbia. **Washington. U. S. Weather Bureau.**

Lat., 38° 54′ N.; long., 77° 03″ W. Elevation, 21 meters.

Instrument: Marvin (vertical pendulum), undamped. Mechanical registration.

Instrumental constants.. V 110, T_0 6

Date.	Character.	Phase.	Time.	Period.	A_E	A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Apr. 3								Microseisms of unusual amplitude from 1:30 p. m. to midnight, accompanying passage of storm off the Atlantic coast.
7		P_N	16 04 40					Phases uncertain. Amplitudes very small.
		S_N	16 13 13					
		F	16 20 00					
23	I_r	eP_N	15 36 52	2			4465	
		iP_N	15 36 55					
		S_N	15 43 05					
		L_N	15 50 46					L doubtful.
		F	16 20 00					

District of Columbia. **Washington. Georgetown University.** F. L. Tondorf, S. J.

Lat., 38° 54′ 25″ N.; long., 77° 04′ 24″ W. Elevation, 42.4 meters. Subsoil: Decayed diorite.

Instruments: Wiechert 200 kg., astatic horizontal pendulums.

Instrumental constants: E: V 165, T_0 5.4, ϵ 0; N: V 143, T_0 5.2, ϵ 0

Date.	Character.	Phase.	Time.	Period.	A_E	A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Apr. 23	I_r	iP_N	15 36 57					E-W not discernible.
		i	15 42 42					
		S_N	15 43 36					
		L?	15 49 10	10		11		
		L?	15 49 42	10				
		F	16 05 54					

Hawaii. Honolulu. Magnetic Observatory. U. S. Coast and Geodetic Survey. Wm. W. Merrymon.

Lat., 21° 19′ 12″ N.; long., 158° 03′ 48″ W. Elevation, 15.2 meters.

Instruments: Milne seismograph of the Seismological Committee of the British Association.

Instrumental constant.. T_0 18.9

Date.	Character.	Phase.	Time.	Period.	A_E	A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Apr. 2		e	6 46 36					Beginning faint and doubtful.
		M	6 51 54		200*			
		C	6 56 12					
2		e	12 12 49					
		M	12 17 06		200*			
		C	12 22 36					
3		P	20 41 12					
		L	20 45 48	22				
		M	20 50 12		1,000*			
		C	20 58 12					
		F	22 53 30					
4		e	9 00 24					
		M	9 10 12	20	200*			
		C	9 14 36					

* Trace amplitude.

Hawaii. **Honolulu. Magnetic Observatory**—Continued.

Date.	Character.	Phase.	Time.	Period. T	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Apr. 4		P	9 59 06					
		L	10 02 06	21				
		M	10 05 06		500*			
		C	10 10 00					
		F	11 16 36					
4		P	15 47 06					
		L	15 58 00					
		M	16 04 00		400*			
		C	16 12 06					
		F	16 46 30					
4		e	18 49 42					
		M	18 55 54		200*			
		C	19 01 36					
		F	19 08 24					
7		P	16 20 24					
		L	16 42 18	21				
		M	16 46 18		500*			
		C	16 55 00					
		F	17 50 30					
8		P	14 19 36					
		L	14 30 18	22				
		M	14 33 24		600*			
		C	14 38 24					
		F	14 48 30					
23		L	15 50 48	20				Preliminary phases indistinct.
		M	15 53 06		300*			
		C	15 59 00					
		F	16 32 00					
24		P	17 26 54					
		L	17 39 30					
		M	17 45 30	22	200*			
		C	17 54 00					
		F	18 06 00					
27		e	11 43 54					
		M	11 55 54		200*			
		F	11 58 24					
29		P	19 27 48					
		L	19 37 30					
		M	19 41 18	20	300*			
		C	19 44 06					
		F	19 50 18					

*Trace amplitude.

Kansas. **Lawrence. University of Kansas.** Department of Physics and Astronomy. F. E. Kester.

Lat., 38° 57′ 30″ N.; long., 95° 14′ 58″ W. Elevation, 304.8 meters.

Instrument: Wiechert.

Instrumental constants.. $\begin{cases} E & 121 & 3.7 & 3.7 \\ N & 126 & 3.7 & 4.5 \end{cases}$ (V, T_0, ε)

Date.	Character.	Phase.	Time.	Period. T	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Apr. 23		P	15 37 26	2			2,300	
		S	15 41 15	2-3				
		L	15 44 00	3-4	15	40		
		F	15 57 00					
27		P	23 53 10	1			200?	
		L	23 53 32		4	3		
		F	24 00 00					

Maryland. **Cheltenham. Magnetic Observatory.** U. S. Coast and Geodetic Survey. George Hartnell.

Lat., 38° 44′ 00″ N.; long., 76° 50′ 30″ W. Elevation, 71.6 meters.

Instruments: Two Bosch-Omori, 10 and 12 kg.

Instrumental constants.. $\begin{cases} E & 10 & 31 \\ N & 10 & 29 \end{cases}$ (V, T_0)

[No earthquake recorded during April, 1915.]

Massachusetts. **Cambridge. Harvard University Seismographic Station.** J. B. Woodworth.

Lat., 42° 22′ 36″ N.; long., 71° 06′ 59″ W. Elevation, 5.4 meters. Foundation: Glacial sand over clay.

Instruments: Two Bosch-Omori 100 kg. horizontal pendulums, undamped (mechanical registration).

Instrumental constants.. $\begin{cases} E & 80 & 23 \\ N & 50 & 25 \end{cases}$ (V, T_0)

Date.	Character.	Phase.	Time.	Period. T	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Apr. 3		L_E	21 04 46	18				
			21 07 43	16-18				F masked by microseisms.
		F	21 25 ..					
7		*0*	*15 58* ..				4,300?	e masked by microseisms.
		$S?_E$	16 11 57					N component restrained by friction.
			16 13 46	8				
			16 15 17	13				
		eL	16 15 59	10				
		L	16 20 44	16				
		F	16 37 00					
23		*0*	*15 29 10*				4,670	
		P_N	15 37 21					P and S strong, L weak.
		P_E	15 37 23					
		S_E	15 43 45	6				
		S_N	15 43 46	6				
		$SR_1?$	15 46 04					
		L_N	15 48 42	16				
		F	.. .. ..					F lost in microseisms.
28		e_E	4 10 04					N record faint.
		L	4 13 28	20				
			4 17 38	20				
		F	4 41 ..					

0 = Time at origin.

Missouri. **Saint Louis. St. Louis University.** Geophysical Observatory. J. B. Goesse, S. J.

Lat., 38° 38′ 15″ N.; long., 90° 13′ 58″ W. Elevation, 160.4 meters. Foundation: 12 feet of tough clay over limestone of Mississippi system, about 300 feet thick.

Instrument: Wiechert 80 kg. astatic, horizontal pendulum.

Instrumental constants.. V 80, T_0 7, ε:1 5:1

[Report for April, 1915, not received.]

New York. **Buffalo. Canisius College.** John A. Curtin, S. J.

Lat., 42° 53′ 02″ N.; long., 78° 52′ 40″ W. Elevation, 190.5 meters.

Instrument: Wiechert 80 kg. horizontal.

Instrumental constants: ———.

[Report for April, 1915, not received.]

New York. **Fordham. Fordham University.** W. C. Repetti, S. J.

Lat., 40° 57′ 47″ N.; long., 73° 53′ 08″ W. Elevation, 23.9 meters.

Instrument: Wiechert 80 kg.

Instrumental constant.. T_0 6

Date.	Character.	Phase.	Time.	Period. T	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Apr. 3-5								Strong microseisms simultaneous with passage of storm of April 3rd.
23	I	eP_N	15 32 32					
		eP_E	15 32 37					
		P_E	15 32 54	2.6	1			
		P_N	15 32 55	4.1		5		
		S_N	15 35 33	4.3		1		
		L_N	15 37 17	4.6				
		M_N	15 38 56	5		7		
		M_E	15 38 50	5	2			
		M_N	15 42 45	6.4		4		
		M_E	15 42 45	5	1			
		F_E	15 58 30					
		F_N	15 59 30					

Panama, Canal Zone. Balboa Heights. Isthmian Canal Commission.

Lat., 8° 57′ 39″ N.; long., 79° 33′ 29″ W. Elevation, —.

Instruments: Two Bosch-Omori 25 kg.

Instrumental constants.. V 8, T_0 20

Date.	Character.	Phase.	Time.	Period. T	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			H. m. s.	Sec.	μ	μ	Km.	
Apr. 23	I....	P_E....	15 33 00	....	....	....	995	A secondary shock at 15h 43m 15s.
		P_N....	15 33 00	....	....	....	......	
		L_N....	15 36 00	....	....	....	......	
		L_E....	15 36 05	....	....	....	......	
		M_E....	15 36 08	....	62	....	......	
		M_N....	15 36 10	....	....	125	......	
		F_E....	15 45 55	....	....	....	......	
		F_N....	15 46 50	....	....	....	......	

Vermont. Northfield. U. S. Weather Bureau. Wm. A. Shaw.

Lat., 44° 10′ N.; long., 72° 41′ W. Elevation, 256 meters.

Instruments: Two Bosch-Omori, mechanical registration.

Instrumental constants.. E: V 10, T_0 15; N: V 10, T_0 16

Date.	Character.	Phase.	Time.	Period. T	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			H. m. s.	Sec.	μ	μ	Km.	
Apr. 3	......	L_N....	21 04 40	....	....	....	......	
		L_N....	21 20 00	16	....	....	......	
		F......	21 45 00	....	....	....	......	
7	......	P_N....	16 07 00	....	....	....	......	Phases uncertain.
		S_N....	16 14 15	....	....	....	......	
		F......	16 25 00	....	....	....	......	
23	I_r....	P_N....	15 37 30	....	....	....	4,945	
		S_N....	15 44 09	....	....	....	......	
		L_N....	15 51 00	....	....	....	......	
		F......	16 15 00	....	....	....	......	

Canada. Ottawa. Dominion Astronomical Observatory. Earthquake Station. Otto Klotz.

Lat., 42° 23′ 38″ N.; long., 75° 42′ 57″ W. Elevation, 83 meters.

Instruments: Two Bosch photographic horizontal pendulums, one Spindler & Hoyer 80 kg. vertical siesmograph.

Instrumental constants.. V 120, T_0 26

Date.	Character.	Phase.	Time.	Period. T	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			H. m. s.	Sec.	μ	μ	Km.	
Apr. 3	......	L......	21 04 00	18	....	....	......	
		L......	21 10 00	18	....	....	......	
		F......	21 23 00	....	....	....	......	

Canada. Ottawa. Dominion Astronomical Observatory—Continued.

Date.	Character.	Phase.	Time.	Period. T	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			H. m. s.	Sec.	μ	μ	Km.	
Apr. 7	......	eP_N...	16 05 33	....	....	....	4440	N partly masked by fairly strong microseisms.
		SR_{1E}.	16 14 27	....	....	....	......	
		SR_{1N}.	16 14 28	....	....	....	......	
		SR_{2N}.	16 15 19	....	....	....	......	
		SR_{3E}.	16 15 44	....	....	....	......	
		eL_E...	16 16 01	10	....	....	......	
		L_E....	{16 20 to 16 26 00}	20	....	....	......	
		F......	16 34 00	....	....	....	......	
23	......	P_N....	15 37 40	4	....	....	5000	
		P_E....	15 37 43	....	....	....	......	
		i......	15 42 41	....	....	....	......	
		S......	15 44 23	....	....	....	......	
		i......	15 46 27	....	....	....	......	
		L?....	15 49 00	20	....	....	......	
		L......	15 51 00	20	....	....	......	
		L_E....	15 56 00	14	....	....	......	
		L_E....	16 04 00	14	....	....	......	
		F......	16 10 00	....	....	....	......	
28	......	L_E....	4 09 00	40	....	....	......	
		L......	4 18 00	18	....	....	......	
		L......	4 26 00	16	....	....	......	
		F......	4 35 00	....	....	....	......	

Canada. Toronto. Dominion Meteorological Service.

Lat., 43° 40′ 01″ N.; long., 79° 23′ 54″ W. Elevation, 113.7 meters. Subsoil: Sand and clay.

Instrument: Milne horizontal pendulum, North. In the meridian.

Instrumental constant.. T_0 18. Pillar deviation, 1 mm. swing of boom = 0.59″.

[Report for April, 1915, not received.]

Canada. Victoria, B. C. Dominion Meteorological Service.

Lat., 48° 24′ N.; long., 123° 19′ W. Elevation, 67.7 meters. Subsoil: Rock.

Instrument: Milne horizontal pendulum, North. In the meridian.

Instrumental constant.. T_0 18. Pillar deviation, 1 mm. swing of boom = 0.54″.

[Report for April, 1915, not received.]

SECTION VI.—BIBLIOGRAPHY.

RECENT ADDITIONS TO THE WEATHER BUREAU LIBRARY.

C. FITZHUGH TALMAN, Professor in charge of Library.

The following have been selected from among the titles of books recently received as representing those most likely to be useful to Weather Bureau officials in their meteorological work and studies:

Baden. Zentralbureau für Meteorologie und Hydrographie.
Niederschlagsbeobachtungen der meteorologischen Stationen im Grossherzogtum Baden. Jahrgang 1914. 1. Halbjahr. Karlsruhe. 1914. 25 p. 29 cm.

Berget, A[lphonse].
Les problèmes de l'atmosphère. Paris. 1914. 2 p.l., 342 p. 18½ cm. (Bibliothèque de philosophie scientifique, dirigée par Gustave Le Bon.)

Berliner, B.
Der Einfluss von Klima, Wetter und Jahreszeit auf das Nerven- und Seelenleben, auf physiologischer Grundlage dargestellt. Wiesbaden. 1914. 3 p. l., 56 p. 26 cm.

Bureau international de l'union télégraphique.
Statistique générale de la radiotélégraphie. Année 1913. Berne. 1915. 14 p. 30 cm.

Carpenter, Alfred, & Wilson-Barker, D.
Nature notes for ocean voyagers . . . with popular chapters on weather, waves, and legendary lore. London, *etc.* 1915. xvi, 181 p. 23 cm.

Deschmann, Rudolph.
Der Föhn in den Alpen. Seine Entstehung und seine meteorologischen Eigenschaften. [1914.] 42 p. 26 cm. (S.-A. aus dem 31. Jahresberichte des K. k. Carl Ludwig-Gymnasiums in Wien.)

Georgii, Walter.
Das Klima von Meiningen in den Jahren 1878–1911. Hildburghausen. 1914. 78 p. plates. 25 cm. (Schriften des Vereins für Sachsen-Meiningische Geschichte u. Landeskunde. 70. Heft.)

Handmann, R.
Wetterbüchlein. Wetterregeln und Wetterperioden, für Touristen zusammengestellt. Ausgabe Juli-September 1914. München. [1914.] 20 p. 15½ cm.

Hawes, Austin F.
The influence of forests on water storage and stream flow. (*In* Proceedings of the Vermont society of engineers, Northfield, Vt., March 12, 1914, p. 20–34.)

Hergesell, H[ugo].
Das deutsche Observatorium in Spitzbergen. Beobachtungen und Ergebnisse. I. Strassburg. 1914. 3 p. l., 65 p. 8 pl. map. 26 cm. (Schriften der Wissenschaftlichen Gesellschaft in Strassburg. 21. Heft.)

Hill, Leonard [Erskine].
Report on ventilation and the effect of open air and wind on the respiratory metabolism. London. 1914. 46 p. plates. 24½ cm. (Great Britain. Local government board. Reports on public health and medical subjects, new ser., no. 100.)

Hooper, John K.
The rainfall in Vermont. (*In* Proceedings of the Vermont society of engineers, Northfield, Vt., March 12, 1914, p. 34–57.)

Johannsen, Heinrich.
Die Beherrschung des Wetters. Schönberg (Mecklb.). [1914.] 45 p. 22 cm.

Kaltenbrunner, Stefan.
Einführung in die neueste und leichte Wettervorherbestimmung, nach 30-jährigen genauen Aufzeichnungen der K. k. Wetterwarte in Wien. Linz. 1914. 34 p. plate. 19 cm.

Kazan. Observatoire météorologique de l'université.
Bulletin, 1914. [Russian text; Russian and French title-page.] Kazan. 1914. 52 p. 2 diagr. 24 cm.
Observations, 1912. [Russian text; Russian and French title-page.] Kazan. 1914. 16 p. 23½ cm.

Kodaikanal and Madras observatories.
Annual report, 1914. Madras. 1915. 2 p. l., 23 p. 33½ cm.

Lühe, Paul.
Beziehungen zwischen Luft- und Meeresoberflächentemperatur in den dänischen Gewässern. [Leipzig. 1914.] 46 p. 24 cm. (Inaug.-Diss.—Berlin.) [S.-A. aus "Internationale Revue der gesamten Hydrobiologie und Hydrographie," Hydrographisches Supplement zu Band 7.]

Manikowske, Wallace.
Windmill electric lighting and power. Fargo, N. Dak. 1913. 39 p. 22 cm. (North Dakota. Agricultural experiment station. Bulletin no. 105.)

Meyer, Adolph F[rederick].
Computing run-off from rainfall and other physical data. 549–648 p. 23 cm. (Reprint: American society of civil engineers. Papers and discussions [1915].)
Graphs of meteorological and hydrological data. [Minneapolis. ©1915.] 47 leaves. 23 cm.

Mississippi River Commission.
Stages of the Mississippi river and of its principal tributaries, for 1914. St. Louis. 1915. lxvi, 79 p. 23 cm.

Monte Rosa. Laboratorii scientifici "A. Mosso."
Atti. Vol. 4. Torino. 1914. viii, 338 p. 24 cm.

Neuhaus, E.
Die Wolken in Form, Färbung und Lage als lokale Wetterprognose. Zürich. 1914. 48 p. plates. 34 cm.

Oña. Colegio máximo de la Compañia de Jesús.
Observaciones meterológicas, [1914]. Oña. 1915. unp. 23½ cm.

Prussia. K. preussisches meteorologisches Institut.
Bericht über die Tätigkeit, im Jahre 1914. Mit einem Anhang enthaltend wissenschaftliche Mitteilungen. Berlin. 1915. 54, (136) p. plate. 28½ cm. (Veröffentlichungen. Nr. 284.)
Ergebnisse der Niederschlags-Beobachtungen im Jahre 1913. Berlin. 1915. xxxiii, 156 p. plate. 34 cm. (Veröffentlichungen. Nr. 283.)

Ryd, V. H.
Bidrag til Bestemmelsen af meteorologiske Elementers Perioder. København. 1915. 4 p. l., 164 p. 25½ cm. [Thesis (Ph. D.)—Copenhagen.]

Sampaio Ferraz, J. de.
Instrucções meteorologicas. (Trabalho destinado aos estacionarios da rêde meteorologica do Brazil.) Bruxelles, *etc.* 1914. 2 v. 24½ cm.

Sievert, Otto.
Wetterkundlicher Unterricht. Methodische Fingerzeige und stoffliche Handreichungen. Berlin. 1914. 56 p. 23 cm.

Staikoff, Staiko D.
Beiträge zur Klimatologie von Bulgarien. Temperaturverteilung. [Berlin. 1914.] 89 p. plate. 26 cm. (Inaug.-Diss.—Berlin.)

Toronto observatory.
Results of meteorological, seismological, and magnetical observations for the year 1913. Toronto. 1914. 47 p. 19½ cm.

Wengler, Fritz.
Die spezifische Dichte des Schnees. [Greifswald. 1914.] 86 p. 23 cm. (Inaug.-Diss.—Berlin.)

Wiedenhoff Siegfried.
Der tägliche Gang der Bewölkung in Japan. [Essen (Ruhr). 1914.] 111 p. plates. 23½ cm. (Inaug.-Diss.—Berlin.)

RECENT PAPERS BEARING ON METEOROLOGY AND SEISMOLOGY.

C. FITZHUGH TALMAN, Professor in charge of Library.

The subjoined titles have been selected from the contents of the periodicals and serials recently received in the Library of the Weather Bureau. The titles selected are of papers and other communications bearing on meteorology and cognate branches of science. This is not a complete index of the meteorological contents of all the journals from which it has been compiled. It shows only the articles that appear to the compiler likely

to be of particular interest in connection with the work of the Weather Bureau.

Cairo scientific journal. Alexandria. v. 8. September, 1914.
Comissopulos, N. A. Frequencies of cloud forms at Helwan, 1904–1913. p. 189–202.

Engineering news. New York. v. 73. February 11, 1915.
Fleming, R. Wind stresses in railroad bridges. p. 252–256.

London, Edinburgh and Dublin philosophical magazine. London. 6 ser. v. 29. 1915.
Pollock, J. A. The nature of the large ions in the air. p. 514–526. (April.)
King, Louis Vessot. On the precision measurement of air velocity by means of the linear hot-wire anemometer. p. 556–577. (April.)
Pollock, J. A. A new type of ion in the air. p. 636–646. (May.)

Nature. London. v. 95. 1915.
Hill, Leonard. Healthy atmospheres. p. 205–207. (Apr. 22.)
Pollock, J. A. The larger ions in the air. p. 286–288. (May 13.)

Royal astronomical society of Canada. Journal. Toronto. v. 9. April, 1915.
Steadworthy, A. Black lightning. p. 173–175.

Royal meteorological society. Quarterly journal. London. v. 41. April, 1915.
Craig, J[ames] I[reland]. A see-saw of temperature between England and Egypt. p. 89–98.
Anderson, Valentine G. The influence of weather conditions upon the amounts of nitric acid and of nitrous acid in the rainfall at and near Melbourne, Australia. p. 99–122.
Geddes, A. E. M. Observations of the upper atmosphere at Aberdeen by means of pilot balloons. p. 123–135.
Mr. J. S. Harding. p. 162. [Obituary.]

Popular science monthly. New York. v. 86. May, 1915.
Grasty, J. Sharshall. The earthquake areas of the earth with special reference to the recent Italian earthquake. p. 446–451.

Scientific American. New York. v. 112. 1915.
[Banks, Charles E.] The barometer and health. p. 380. (Apr. 24.) [Reprinted from "Health News," issued by U. S. Public health service.]
Measuring atmospheric comfort. p. 431. (May 8.)

Scientific American supplement. New York. v. 79. 1915.
Pring, J. N. The formation of ozone in the upper atmosphere. p. 286–287; 303. (May 1, 8.) [Extracts from "Science Progress," Jan., 1915.]

U. S. Department of agriculture. Yearbook. Washington. 1914.
Thiessen, Alfred H. Story of the thermometer and its uses in agriculture. p. 157–166.

Yearbook of wireless telegraphy and telephony. London. 1915.
Lempfert, R[udolf] G[ustav] K[arl]. The application of wireless telegraphy to meteorology. p. 622–627.

Académie Roumaine. Bulletin. Bucarest. 3 année. 1914/15.
Otetelişanu, Enric. La variation de la pression atmosphérique pendant l'éclipse solaire du 21 août, observée en Roumanie. p. 233–238. (Nr. 8.)
Minovici, St., & Grozea, E. Recherches sur l'air de la ville de Bucarest. p. 275–286. (Nr. 9.)

Académie des sciences. Comptes rendus. Paris. Tome 160. 15 février 1915.
Galitzine, B[oris]. Sur le tremblement de terre d'Italie du 13 janvier 1915. p. 247–250.

Archives des sciences physiques et naturelles. Genève. Tome 39. 15 mars 1915.
Schmid, F[riedrich]. Nouvelles observations sur la nature de la lumière zodiacale. p. 237–246. [Author believes the zodiacal light to be the reflection of solar light in a lens-shaped terrestrial atmosphere.]

Astronomie. Paris. 29 année. Mars 1915.
Paolis, Armand de. Le tremblement de terre de l'Italie centrale (13 janvier 1915). p. 99–108.
Entend-on le tonnerre en pleine mer? Plus grande distance à laquelle le tonnerre se fait entendre. p. 109–112.

Annalen der Hydrographie und maritimen Meteorologie. Berlin. 43. Jahrgang. Heft 4. 1915.
Wegener, Alfred. Neuere Forschungen auf dem Gebiet der Meteorologie und Geophysik. p. 159–168.
Schmidt, Wilhelm. Strahlung und Verdunstung an freien Wasserflächen; ein Beitrag zum Wärmehaushalt des Weltmeers und zum Wasserhaushalt der Erde. p. 169–178.

Meteorologische Zeitschrift. Braunschweig. Band 32. April, 1915.
Schwalbe, G[ustav]. Über Frühgewitter. p. 145–153.
Dorr, Josef. Szintillationsbeobachtungen auf dem Sonnwendstein (1907–1908). p. 153–167.
Defant, A[lfred]. Über das Energiespektrum der Sonne. p. 167–180.

Metroeologische Zeitschrift—Continued.
Köppen, W[ladimir]. Monatliche Perioden in der Witterung. Hp. 180–185.
ann, J[ulius] v. C. Braak, Über das Klima von (Holländisch-) Neu-Guinea. p. 185–186. [Abstract of memoir in Dutch by C. Braak.]

Mitteilungen aus den deutschen Schutzgebieten. Berlin. 28. Band. 1. Heft. 1915.
Schlikker, Bernhard. Beitrag zu den Regenverhältnissen im küstennahen Gebiete von Deutsch-Ostafrika. p. 1–41. [With rainfall chart.]
Heidke, P. Meteorologische Beobachtungen aus Togo. Teil V. Zusammenstellung der Monats- und Jahresmittel aus dem Jahre 1913 an 12 Beobachtungsstationen. p. 42–73.

Naturwissenschaften. Berlin. 3. Jahrgang. 1915.
Tams, E[rnst]. Über die Frequenz der Nachstösse starker Beben. p. 145–150. (12. März.)
Tams, E[rnst]. Das italienische Erdbeben vom 13. Januar 1915. p. 189–191. (9. April.)

Prometheus. Leipzig. Jahrgang 26. März 27, 1915.
Walter, B. Das Wesen der Kugelblitze. p. 408–410.

Prussia. Königlich preussisches meteorologisches Institut. Abhandlungen. Berlin. Band 5. Nr. 2. 1915.
Hellmann, G[ustav]. System der Hydrometeore. p. 1–27. [Author aims to present a complete enumeration of the forms of aqueous precipitation and to standardize the nomenclature.]

Geografia. Novara. anno 3. Gennaio–Febbraio 1915.
Magistris, Luigi Filippo de. Il terremoto marsicano del 13 gennaio 1915. p. 6–30.

NOTES FROM THE WEATHER BUREAU LIBRARY.

By C. FITZHUGH TALMAN, Professor in charge of Library.

A LIST OF METEOROLOGICAL ISOGRAMS.

The subject of the meteorological isograms was somewhat fully discussed by the present writer in the Scientific American Supplement of Nov. 12, 1910, and in that connection the writer presented a list of such named isograms as had come to his notice. Further search of meteorological literature, as well as the recent growth of the vocabulary, enables him to present herewith a much larger list and one that is believed to be nearly complete. The author will be glad to have his attention called to any that he has overlooked. The isograms of terrestrial magnetism, and many isograms that are of general application in physics and are therefore occasionally met with in meteorological diagrams (e. g., *isenergic* and *isentropic*), lie beyond the scope of the present compilation.

The term *isogram* was suggested by Francis Galton in 1889[1] as a convenient generic designation for lines, on a chart or diagram, indicating equality of some physical condition or quantity. These lines are, of course, used in many sciences, but much the largest number of those to which particular names have been assigned belong to meteorology. In German such lines have sometimes been called *Isolinien*, or *Isarithmen* ("iso-lines" or "isarithms"). Dr. W. N. Shaw, in his "Forecasting Weather" (London, 1911), calls them *isopleths*, but the latter term has for years borne a more specific meaning in meteorology (as explained below), and its use in the same broad sense as *isogram* is to be regretted, as leaving the isopleth in the narrower sense without a distinctive name. As Hann says in his "Lehrbuch der Meteorologie" (3d ed., 1915, p. 91) the name *isopleth* is literally appropriate for any line connecting equal numerical values, but custom has limited its use to a particular class of such lines. Meteorological isograms have sometimes been known as *isometeoric lines*, and those used in climatology as *isoclimatic lines*.

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[1] Nature, 40, 1889, p. 651.

Magnetic isograms were published (by Halley) as early as 1701, and appeared on manuscript charts even earlier, but the first meteorological isograms were Humboldt's isotherms of the globe (1817). Humboldt also suggested the use of two other meteorological isograms: viz, the *isothere*, connecting places having the same temperature in summer, and the *isochimenal*, connecting those having the same temperature in winter; but he did not actually draw them. He contented himself with a description of their course with respect to the annual isotherms, and with noting the summer and winter temperatures at several points on his isothermal chart.

Theoretical isobars for the Atlantic and Indian oceans were drawn by H. K. W. Berghaus in 1839; in accordance with the views then prevailing they were straight lines parallel to the equator. The first isobars based upon actual data of observation were those drawn for France by Renou, in 1864, and the first isobars for the whole globe were published by Buchan (who called them *isobarometric lines*) in 1868.

In recent years the number of named isograms has increased rapidly, but they have received tardy recognition in the dictionaries, and even in scientific reference-books. One result of this is seen in the frequent coining of synonymous expressions. A writer who finds it convenient to apply a name to an isogram can not readily ascertain whether a suitable one has already been proposed; he therefore proceeds to christen it *à sa guise*.

The application of the names of the isograms is, and should be, somewhat elastic. Thus an isotherm is *any* isogram of temperature; not merely of mean annual temperature, as was stated, until very recently, in the English dictionaries. Similarly, the *isotalantose* should be defined as *any* isogram of range; the element and period in question being indicated by a qualifying expression when necessary; but as a rule this can be gathered from the context. In other words, the names of the isograms should have a more or less generic application; otherwise the terminology of these lines would need to be multiplied *ad infinitum* to satisfy all the requirements of the graphic representations of this character used in meteorology.

The following list indicates the date of introduction and the author of each term and the earliest instance of its use, so far as this information could be obtained by the compiler:

aerotherm. Isopleth showing the daily march of temperature over a given place up to a few meters above the ground; drawn for comparison with geotherms. (T. Homén, Acta Soc. sci. Fenn., **23**, no. 3, 1897, p. 95.)

anisallobar. Isogram of rise of barometric pressure in a given time; a positive isallobar. (N. Ekholm, "Das Wetter auf der Nordsee whärend der ersten Hälfte von Juni, 1911," 1913, p. 14.)

baroisobar. Same as *isallobar*. (F. G. Friesenhof, Met. Zeit., **22**, 1905, p. 235.)

chionosynchrone. Isogram of the duration of snow on the ground. (E. W. Kaminska, Bull. Acad. sci., Cracovie, sér. A, 1912, p. 874.)

choroisotherm. Isotherm used in representing the distribution of temperature in space; the common form of isotherm, as on isothermal maps and weather maps; distinguished from the *chronoisotherm*, which shows the distribution of temperature in time. (W. Köppen, Met. Zeit., **2**, 1885, p. 287, foot-note 3.)

chronoisotherm. Isopleth of temperature; a thermoisopleth. (R. H. Scott, "Elementary meteorology," Lond., 1883, p. 49.)

chthonisotherm. A line drawn from the equator poleward along a meridian, passing through points beneath the earth's surface having the same temperature as the surface at the equator. (G. Bischof, "Die Wärmelehre des Innern unsers Erdkörpers, 1837, p. 174–175.)

equiglacial line. Isogram of the condition of the ice in rivers, lakes, harbors, etc. There are three classes of these lines; viz., *isopectics*, *isotacs*, and *isopags* (all defined below). Some writers apply this term only to the isopag (e. g., H. H. Hildebrandsson, Ann. Bur. cent. mét. France, 1878, I, p. C. 34. An example of the broader use occurs in S. Günther, "Lehrbuch der phys. Geographie," 1891, p. 250.)

equipluve. Isogram of pluviometric coefficient. This isogram is analogous to, but not identical with, the *rainfall isomer*. Cf. *isomer*. (B. C. Wallis, Scot. Geogr. Mag., **30**, 1914, p. 364. Equipluves were drawn by A. Angot in 1895 but not so named.)

equipotential curve. In atmospheric electricity, an isogram of potential.

geoisotherm (*geisotherm*). Same as *isogeotherm*.

geotherm. Isopleth showing the daily march of temperature at various depths in the ground. (T. Homén, Bidrag till kännedom af Finlands natur och folk, **54**, 1894, p. 234.)

homobront. Same as *isobront*.

hygropleth. Isopleth of dew-point temperature. (T. Homén, Acta Soc. sci. Fenn., **23**, no. 3, 1897, p. 96.)

hypertherm. Isogram of positive departure from normal temperature. (H. Arctowski, "L'enchaînement des variations climatiques," 1909, p. 94.)

hypotherm. Isogram of negative departure from normal temperature. Hypertherms and hypotherms are special cases of the *isametral*. (H. Arctowski, "L'enchaînement des variations climatiques," 1909, p. 94.)

hypsoisotherm. Isotherm drawn on a vertical section of the atmosphere (sometimes also of the ground) to show the distribution of temperature in the vertical. (Translation of the term "Höhenisotherme" used by H. and A. Schlagintweit, "Untersuchungen über die physikalische Geographie der Alpen," 1850, Tafel viii and ix.)

isabnormal (*isoabnormal*). Same as *isanomal*. (H. W. Dove, "Die Verbreitung der Wärme auf der Oberfläche der Erde," 1852, Charte IV, English subtitle.) An application of this term to isametrals of barometric pressure, formerly entered on synoptic weather charts, is recorded in R. Abercromby's "Weather," 1887, p. 7.

isactine. Isogram of chemical intensity of solar radiation. (R. Radau, "La lumière et les climates," 1877, p. 72. Probably not earliest use.)

isalea. Isogram of the amount of insolation, expressed in thermal units. (J. Westman, Nova acta Reg. soc. sci., Upsala, ser. 4, **2**, no. 7, 1910, p. 21.)

isallobar. Isogram of the amount of change in barometric pressure within a specified period. (N. Ekholm, Met. Zeit., Hann-Band, 1906, p. 230. Previously named *baroisobar*.)

isallotherm. Isogram of the amount of change in temperature within a specified period. (A. Defant, Sitzb. K. Akad. Wiss., Wien, Abt. IIa, **119**, 1910, p. 740.)

isametral. Isogram of the temporary departure of an element, during a particular period, from the local normal. (H. W. Dove, "Die Monats- und Jahresisothermen in der Polarprojection," 1864. [Not paged.])

isanakatabar. Isogram of pressure-amplitude during the passage of cyclones and anticyclones. (W. J. S. Lockyer, "Southern hemisphere surface-air circulation," 1910, p. 10–11.)

isanemone. Isogram of wind velocity. (L. Brault, Ann. Bur. cent. mét. France, 1880, IV, p. ix.)

isanomal (*isanomalous line*). Isogram of anomaly; i. e., of the departure of the local mean value of an element from the mean pertaining to the latitude. (H. W. Dove, "Die Verbreitung der Wärme auf der Oberfläche der Erde," 1852, p. 20.)

isanthesic line (*isanthesical line; isantheric line; isanther*). In phenology, the isochrone of the first blossoming of any specified plant. (L. A. J. Quetelet, Bull. Acad. roy. sci. Bruxelles, **9**, 1842, p. 67.)

iseoric line. Same as *isotalantose.* (D. Ragona, Annuario della Società dei naturalisti di Modena, 1866, p. 41.)

isoabnormal. See *isabnormal.*

isoamplitude, line of. Isogram of range or amplitude. (Cited as a "mot mal forgé" by E. de Martonne, "Traité de géographie physique," 1909, p. 126. Source not stated.)

isoatmic line. Same as *isothyme.* (T. Okada, Bull. Centr. meteorol. observatory of Japan, **1**, 1904, p. 14.)

isoaurore. Isogram of frequency of auroras; also called *isochasm.* (S. Tromholt, "Under the rays of the aurora borealis," 1885, **1**, p. 248. Probably used previously by the same writer.)

isobar (*isobaric line; isobarometric line;* formerly also *isobare*). Isogram of barometric pressure. (H. K. W. Berghaus, "Physikalischer Atlas," "Vorbemerkung," 1838, p. 63. The form *isobare*, i. e., the German singular unaltered, was used by A. K. Johnston in his "Physical atlas," 1849.)

isobarometric line. Isogram of mean monthly range of barometric pressure. (L. F. Kämtz, Schweiggers Jahrb. Phys und Chem., 1827, p. 168. The inappropriateness of the term in this sense was recognized by the author, and it is now obsolete.)

isobathytherm. Isogram of the depth at which a given temperature occurs—applied to temperatures in the ocean. (C. Wyville Thomson, Proc. Roy. soc. Lond., **24**, 1876, p. 465, foot-note. Most dictionaries erroneously define this term as synonymous with *isothermobath.*)

isobront (*isobrontal line; isobronton*). A thunderstorm isochrone; usually an isochrone of the first thunder, loudest thunder, or beginning of rain in a thunderstorm. Also called *homobront.* (W. von Bezold & C. Lang, Bavaria, K. meteorol. Central-Station, "Beobachtungen der meteorol. Stationen," **1**, 1879, p. xxxvi.)

isochasm. Same as *isoaurore.* (H. Fritz, Vierteljahrsschr. Naturf. Gesell. Zürich, **12**, 1867, p. 354.)

isocheim. (Also *isochime, isochimene, isocheimal, isochimal, isocheimic, isochimonal, isocheimonal, isochimenal, isocheimenal.*) Isogram of winter temperature. (A. von Humboldt, Mém. de phys. et de chim. de la Soc. d'Arcueil, **3**, 1817, p. 529.)

isochion. Isogram of snow. This term has been applied to isograms of (1) depth of snow lying on the ground, (2) number of days with snow, and (3) altitude of snow-line.

isoclimatic line. Any isogram of climate.

isocoefficient. Isogram of the pluviometric coefficient. (Nonce-use in "Das Wetter," **31**, 1914, p. 275.)

isocryme (*isocrymal; isocrymic line*). Isotherm for a specified coldest period of the year—applied chiefly to water-temperatures. (J. D. Dana, Amer. journ. sci., (2) **16**, 1853, p. 153–154.)

isodense. Same as *isopycnic.* (N. Ekholm, Met. Zeit., **7**, 1890, p. 378, foot-note 2.)

isodiaphore. Isogram of difference; e. g., between the mean values of an element for two specified months. Originally used in a comparison of the unreduced barometric pressure at different seasons. (R. Spitaler, "Die periodischen Luftmassenverschiebungen," 1901, p. 16. Applied by G. Roster, "Climatologia d'Italia," 1909, p. 157, to an isogram of annual range of temperature.)

isodrome. See *thermoisdrome.*

isodynam. An isogram of force; in meteorology, generally of wind-force, and then synonymous with *isanemone.*

isoeral. Isogram of the temperature in spring.

isogeotherm. (Also *geisotherm* or *geoisotherm.*) Isogram of the temperature of the ground. Probably applicable to any form of subterranean isotherm, but was applied originally to an isogram of the temperature at the depth of no annual variation—assumed to average about 25 meters—the data being obtained from the temperature of springs. (A. T. Kupffer, Ann. der Phys. u. Chem., **15**, 1829, p. 180.)

isogon. Isogram of wind-direction. (J. W. Sandström, K. Svenska Vetenskapsakad. Handl., **45**, no. 10, 1910, p. 12.)

isogradient. Isogram of gradient; applied by J. Kleiber to the isogram of horizontal pressure-gradient. (Met. Zeit., **7**, 1890, p. 401.)

isohel (*isohelic line*). Isogram of duration of sunshine. (H. König, Abh. [Nova acta] der Kais. Leop.-Carol. deutschen Akad. der Naturf., **67**, no. 3, 1896, p. 324.)

isohyet (*isohyetal; isohyetose*). Isogram of the amount of rainfall.

isohygrometric line. Isogram of atmospheric moisture. (D. G. Dalgado, "Climate of Portugal," 1914, p. 104, calls the isogram of relative humidity an *isohygro.*)

isohyst. Same as *isohyet.*

isokatanabar. Isogram of monthly range of barometric pressure. Same as Kämtz's *isobarometric line.* (W. Köppen, Met. Zeit., **29**, 1912, p. 502.)

isomenal. Isogram of monthly mean; especially of temperature.

isomer. Isogram of the percentage of an annual total occurring in a specified month, or other period. (C. Salter, Quar. journ. Roy meteorol. soc., **40**, 1914, 323. See further *ibid.*, **41**, 1915, p. 14.)

isometabole. Isogram of interdiurnal variability of any element; i. e., of average change between observations 24 hours apart. (H. Bahr, Met. Zeit., **28**, 1911, p. 500.)

isometeoric line. A meteorological isogram.

isometeorograde. Isogram of "grade," in a notation proposed by C. Ritter. See op. cit. (Int. meteorol. Cong., Paris, 1889, Mémoires, p. 91.)

isometoporal. Isogram of the temperature in autumn.

isoneph (*isonephelic line*). Isogram of cloudiness. (E. Renou, Ann. Soc. météorol. de France, **27**, 1879, p. 126.)

isoomber. An untenable synonym of *isothyme.*

isoorthotherm. Isogram of "orthotemperature." See op. cit. (F. Kerner von Marilaun, Sitzb. K.k.Akad. Wiss., Wien, **122**, IIa, 1913, p. 290.)

isopag. The equiglacial line indicating the duration of the ice-cover in rivers, harbors, lakes, etc. (K. L. Veselovskii, 1857.)

isoparallage. Same as *isotalantose.* (C. H. D. Buys Ballot, "Verdeeling der warmte over de aarde," 1888, p. 16, cites F. W. C. Krecke, Verslagen v. de Sectievergaderingen, Prov. Utrechtsche genootsch. v. Kunsten en Wetensch., 1862.)

isopectic. The equiglacial line of the first ice in winter. (M. Rykachev, "Über den Auf- und Zugang der Gewässer des Russischen Reiches," 1887, p. 47.)

isophane. In phenology, isochrone of the occurrence of any periodic phenomenon of plant life. (S. Günther,

"Die Phänologie," 1895, p. 40, cites H. Hofman. The term is defined by Hoffmann in Thiel's Landw. Jahrbücher, **14**, 1885, p. 842, but may be earlier.)

isophasm (of pressure). Term applied by W. Krebs to an isogram of the percentage of agreement of local pressure variations with those occurring in India. (Weltall, **6**, 1906, p. 120.)

isophenological line. Any phenological isochrone.

isophthor. Isogram of damage by a storm. (A. Walter, "The sugar industry of Mauritius," 1910, p. 150.)

isopleth. A line showing the variation of an element in relation to two coordinates; one of the coordinates representing the time of the year (month), and the other usually the time of day (hour), but sometimes space (especially altitude).[2] (Introduced into meteorology by L. Lalanne, 1843; named by Ch. Vogler, "Anleitung zum Entwerfen graphischer Tafeln," 1877, p. 7.)

isopycnic. (Also *isopyc*, *isopyk*, *isodense*, *isostath*.) Isogram of atmospheric density. (Met. Zeit., **7**, 1890, p. 378, foot-note 2.)

isostath (*isostathmic line*). Same as *isopycnic*. (C. Abbe, Rept. Chief Signal Officer, U. S. A., 1889, pt. 2, p. 95.)

isosthene. Line along which the atmosphere is in equilibrium. (M. Möller, Met. Zeit., **1**, 1884, p. 242.)

isotac. The equiglacial line of the breaking up of the ice in spring. (M. Rykachev, "Über den Auf- und Zugang der Gewässer des Russischen Reiches," 1887, p. 40.)

isotalantose (*isotalantous line*). Isogram of range or amplitude; generally applied to the mean annual range of temperature. Same as *isoparallage*. (A. Supan, Zeit. f. wiss. Geogr., **1**, 1880, p. 141.)

isothere (*isotheral*). Isogram of summer temperature. (A. von Humboldt, Mém. de phys. et de chim. de la Soc. d'Arcueil, **3**, 1817, p. 533.)

isotherm (*isothermal* [*line*, etc.], *isothermous line*). Any isogram of temperature. (*Isothermal circles*, *lines*, or *parallels* were first described by A. von Humboldt in the Latin "Prologomena" prefixed to Bonpland, Humboldt and Kunth's "Nova genera et species plantarum," **1**, 1815. See p. xxviii and *passim* thereafter. Such lines were first published by Humboldt in connection with the separate reprints of his memoir, "Des lignes isothermes et de la distribution de la chaleur sur le globe," from Mém. de phys. et de chim. de la Soc. d'Arcueil, **3**, 1817. They did not accompany this memoir as originally published.)

isothermobath. Isogram of temperature in a vertical section of a body of water. (C. Wyville Thomson, Proc. Roy. soc. Lond., **24**, 1876, p. 465, foot-note.)

isothermohyps. A thermoisopleth, one coordinate of which is altitude.

isotherombrose. Isogram of summer rainfall.

isothyme. Isogram of amount of evaporation; an isoatmic line. (C. F. Marvin, U. S. Mo. weather rev., **37**, 1909, p. 142.)

katisallobar. Isogram of fall of barometric pressure in a given time; a negative isallobar. (N. Ekholm, "Das Wetter auf der Nordsee während der ersten Hälfte von Juni, 1911," Copenhagen, 1913, p. 14.)

palæo-. Prefixed to the name of an isogram, denotes that the latter pertains to some past geologic epoch; as, *palæoisotherm*.

synbarometrical line. Isobar on a synchronous weather chart. (H. Hennessy, Trans. Roy. Irish acad., **24**, 1871, p. 425. [Read Jan. 14, 1867.])

syngeothermal line. Isogram of the surface temperature of the ground at a given moment. (H. Hennessy, Trans. Roy. Irish acad., **24**, 1871, p. 415. [Read Jan. 14, 1867.])

synthermal line. An isotherm based on simultaneous observations. (H. Hennessy, Trans. Roy. Irish acad., **24**, 1871, p. 376. [Read Jan. 14, 1867.])

thermoisodrome. Isogram of the "thermodromic quotient"—a mode of expressing the contrast between spring and autumn temperatures. (F. von Kerner, "Thermoisodromen," Abh. K. k. geogr. Gesell., Wien, **6**, 1905, no. 3.)

thermoisopleth. An isopleth of temperature; a chronoisotherm. (F. Erk, Met. Zeit., **2**, 1885, p. 286.)

[2] In its most familiar form the diagram of isopleths shows the normal or average value of a meteorological element at any hour of the day during any month of the year. The two ostensible time-coordinates really correspond, respectively, to the orbital and rotational positions of the earth. For an example of an isopleth diagram in which one coordinate represents altitude, see J. Hann, "Handbuch der Klimatologie," 3d ed., Stuttgart, **1**, 1908, p. 217. In two charts of water-temperature published in Annalen der Hydrographie, **39**, 1911, Tafeln 36 and 37, the coordinates are, respectively, time and latitude, and time and longitude.

SECTION VII.—WEATHER AND DATA FOR THE MONTH.

THE WEATHER OF THE MONTH.

P. C. DAY, Climatologist and Chief of Division.

Pressure.—The distribution of the mean atmospheric pressure over the United States and Canada, and the prevailing directions of the winds, are graphically shown on Chart VII, while the average values for the month at the several stations, with the departures from the normal, are shown in Tables I and III.

For the month as a whole the barometric pressure was high over all sections east of the Rocky Mountains, except in Montana, the northern portions of North Dakota and Minnesota, and in the Canadian Provinces from the upper Lake region westward. The most marked positive departures occurred in the central valleys and in Maine and the Canadian Provinces to the northeastward, the departures being rather marked in the latter region. Over all other portions of the country the means for the month were below the normal, except the western portion of the State of Washington, where they were near or slightly above, the greatest negative departures appearing in central California, northwestern Nevada, southern Idaho, western Montana, and the eastern Rocky Mountain slope of the Canadian Provinces.

The month opened with relatively high pressure over all districts, except the New England States and the north Pacific slope, where moderately low pressure prevailed. During the first decade a succession of low and high pressure areas followed each other across the country with moderate movement but rather marked regularity. Early in the second decade a rather extensive high pressure area enveloped the greater part of the country east of the Rocky Mountains, which was accompanied by generally fair weather. These conditions continued until near the end of the decade when they were replaced by generally low pressure in nearly all sections. During the third decade, relatively low pressure prevailed over the greater part of the country much of the time and was accompanied by frequent showers. The month closed with an area of low pressure extending from the Lake region to the South Atlantic States, and another extensive and rather marked low area covering the Rocky Mountain region and westward to the Pacific. Elsewhere the pressure was near the normal.

The distribution of the highs and the lows was generally favorable for southerly and southeasterly winds over the west Gulf States, the Mississippi Valley and the southern portion of the Plains States, and southerly and southwesterly over the Ohio Valley and the southwestern portion of the Lake region. Elsewhere variable winds prevailed.

Temperature.—During the first few days of April the temperature was unseasonably low throughout eastern and southern districts, with frosts in most parts of the east Gulf and South Atlantic States, but west of the Rocky Mountains the weather continued considerably warmer than usual for the season of the year.

As the first week advanced the weather became warmer generally over eastern districts, and by the middle temperatures were high for the season in those sections, but at the same time they had become relatively low over the Rocky Mountain and Plateau regions of the West. However, by the close of the week temperatures had fallen considerably in the upper Mississippi and Ohio Valleys, the region of the Great Lakes, and over the Middle Atlantic States, with a general tendency to cooler weather over eastern districts, but with somewhat warmer from the Rocky Mountains westward.

For the week as a whole the average temperatures were above the normal in all portions of the country, except small districts in the southern Rocky Mountain region and extreme South. In the middle Mississippi and lower Ohio Valleys and portions of the Lake region and Northeastern States the averages were from 8° to 10° above the weekly normal.

During the early part of the second week frosts were reported from points in the Ohio Valley and Middle Atlantic States. In other portions of the country there was a tendency to higher temperatures, except in the far West, where it was somewhat cooler. By the middle of the week temperatures had risen to near or above the normal in all portions of the country, and in the Plains States and Northwest the weather had become decidedly warm, and continued unusually warm over the northern districts to eastward of the Rocky Mountains at the close of the week.

The week as a whole was unusually warm in the central valleys and Northwest, especially in the Dakotas and Montana, where the averages ranged from 15° to 20° above the normal. The week was moderately warm over the North Atlantic States and in all districts to westward of the Rocky Mountains. It was slightly cooler than the average from the lower Lake region southward to the Atlantic coast, and over the Florida Peninsula, western Texas, and portions of New Mexico.

During the latter part of the week, at points in the Lake region and along the middle Gulf coast, temperatures equaled or exceeded any previously reported during the past 40 years in those regions for the same period.

The weather continued warm at the beginning of the third week in practically all portions of the country, and especially so in the Ohio Valley and to the eastward, but by the middle of the week decidedly cooler weather overspread the Northeastern States, and temperatures nearly 10° below freezing were reported from exposed points in the interior of New England. Cooler weather had also advanced into the far Northwest, but in other portions of the country temperatures continued high. During the latter part of the week warm weather became general from the Mississippi Valley to the Atlantic coast, but it continued cool to westward of the Rocky Mountains.

For the week as a whole the average temperatures were abnormally high in the Lake region, central valleys, and most eastern districts, and they continued slightly below the normal over most of the Pacific coast region. The maximum temperatures over much of the Lake region and the Ohio Valley and eastward to the Atlantic coast during the early part of the week were in many cases the highest ever recorded during April in those regions.

The fourth week opened with continued warm weather in the great central valleys, but in the Northeastern States cooler weather had developed and there was a

tendency to lower temperature in the Northwest, and it continued cool over the Pacific Coast States. As the week advanced cooler weather overspread the central valleys and by the end temperatures had become nearly normal in all districts to eastward of the Rocky Mountains. In the far West the weather had become unsettled, and by the middle of the week severe cold for the season of the year had overspread portions of the Plateau region and snow was falling from southern Idaho to northern Arizona. During the latter part of the week there was a tendency to cooler weather in all eastern districts, while in the far West abnormally low temperatures continued, especially in the Plateau region, where in some portions they were below 10°, a most unusual occurrence so late in the spring.

The average temperature for the week as a whole was above the normal over all districts to eastward of the Rocky Mountains, except along the New England coast, and it was decidedly warm over the Central and Southern States and at a few points in the Lake region. West of the Rocky Mountains it was decidedly cold, especially in the far Southwest, where the average ranged from 10° to 14° below the normal.

Precipitation.—The month opened with a general deficiency in soil moisture from the Mississippi Valley eastward, and in portions of Texas, the greater part of the Plateau region, and in the far Northwest, the deficiency being most marked in the Ohio Valley, where the fall from January 1 to April 30 was in many cases but little more than one-half the normal, and similar conditions prevailed in portions of Montana and North Dakota. In the Plains States and Southwest, however, the amount of moisture was unusually large.

During the first few days of April a rain and snow area moved northward along the Atlantic seaboard from Florida to New England, but its influence did not extend far inland, and the precipitation, mostly snow and unusually heavy for the season of the year, was confined to a narrow belt along the coast. About the middle of the week unsettled weather with local rains set in over the western Plateau region, and moved slowly eastward, accompanied by some heavy local falls in the Rocky Mountain and Plains regions, and moderate to light showers over central and northern districts to the eastward.

Generally fair weather prevailed throughout the greater part of the second week in nearly all districts, except early in the week showers occurred in the central part of the Plateau and Mountain districts, some heavy falls occurring in portions of New Mexico and western Texas, where rainy conditions prevailed for several days, and during the latter part of the week some local heavy rains occurred in portions of the West Gulf States. The total precipitation for the week was greatly deficient, many large areas in the Atlantic and Gulf States, Ohio Valley, and Plains States being without rain during the entire period. In marked contrast the fall in the southern portion of the Plains region and in the Southwest was unusually large.

During the third week local rains, in some cases remarkably heavy, were of daily occurrence over considerable areas of the Plains States and Southwest. Heavy rains set in over portions of Texas and Oklahoma early in the week, extending as light showers by the middle of the week into portions of the middle and lower Mississippi and Ohio Valleys, while local showers occurred in the Rocky Mountain region and far Southwest, and rains became fairly general in the Great Plains region with some unusually heavy falls. During the latter part of the week heavy rains again occurred in portions of the Plains States and Texas, and at the close of the week there were local showers in the upper Mississippi Valley, northern New England and the far Southwest. For the week as a whole the precipitation was far in excess of the average in the central and southern portions of the Great Plains and over much of the west Gulf District and in the Southwest, and there was sufficient rain for the time being in large portions of the Mississippi and Ohio Valleys and in the Mountain and Plateau regions of the West, but over the middle and east Gulf and Atlantic Coast States and much of the Lake region there was no appreciable precipitation during the week.

Local showers occurred during the first few days of the fourth week in the Lake region and over the more eastern districts, but there was little rain in the interior and western portions of the country. During the latter part of the week unsettled weather with rain or snow prevailed very generally throughout the Mountain and Plateau regions extending into Texas and the Southwest, with some heavy rains in west-central Texas and over the eastern districts of Oregon and Washington. These unsettled conditions moved slowly eastward with more or less precipitation over wide areas. Snow occurred over considerable areas in the Plateau and Mountain regions of the West, the fall exceeding 12 inches at Tonopah, Nev., and doubtless much more fell at the higher elevations. By the end of the week local showers, mostly light, had occurred over considerable areas in the Ohio Valley and eastward to the Atlantic coast, and from the Lake region westward to the Missouri Valley. The total precipitation for the week, while not large was generally ample in all sections to the westward of the Mississippi, while to the eastward the amounts were deficient, and in many small areas the fall was too light to afford any material relief from the drought that had prevailed for the past two months.

GENERAL SUMMARY.

The weather of the month was characterized by generous precipitation in the Southwest, especially in Oklahoma and Texas, and the absence of appreciable precipitation in nearly all districts from the Mississippi eastward, and over the greater part of the Plateau region and the far Northwest until near the end of the month when moderate rainfall somewhat relieved the droughty conditions which had continued for the past two months in these districts, except that in many small areas east of the Mississippi the fall was too small to furnish any appreciable relief.

Likewise the high temperatures that occurred during the second decade in the Lake region, Ohio Valley and eastward to the Atlantic and along the middle Gulf coast were unusual, some of the highest temperatures ever reported for April in these regions being recorded. In marked contrast during the latter part of the month unusually cold weather with heavy snow occurred in portions of the Plateau and Rocky Mountain regions, the average temperature in the far Southwest during the last week ranging from 10° to 14° below the normal, a most unusual departure for the season of the year in that district where temperature changes are usually much less pronounced than in the districts to the northward.

Average accumulated departures for April, 1915.

Districts.	Temperature. General mean for the current month.	Temperature. Departure for the current month.	Temperature. Accumulated departure since Jan. 1.	Precipitation. General mean for the current month.	Precipitation. Departure for the current month.	Precipitation. Accumulated departure since Jan. 1.	Cloudiness. General mean for the current month.	Cloudiness. Departure from the normal.	Relative humidity. General mean for the current month.	Relative humidity. Departure from the normal.
	°F.	°F.	°F.	Ins.	Ins.	Ins.	0–10		P.ct.	
New England	47.8	+ 4.2	+12.4	1.99	−1.10	−2.30	6.0	+0.5	73	0
Middle Atlantic	55.7	+ 5.2	+ 9.8	1.90	−1.20	−1.30	4.7	−0.5	65	− 2
South Atlantic	62.7	+ 1.4	− 3.2	1.59	−1.80	−4.00	3.4	−1.2	69	− 3
Florida Peninsula	70.1	− 3.3	−13.5	1.34	−0.60	+2.40	3.6	−0.2	72	− 2
East Gulf	66.1	+ 1.5	− 7.8	0.54	−3.50	−5.00	3.6	−1.3	65	− 5
West Gulf	66.3	+ 0.5	− 6.3	6.23	+2.70	+1.30	6.4	+1.3	76	+ 4
Ohio Valley and Tennessee	59.5	+ 4.8	+ 2.3	1.20	−2.40	−5.90	4.6	−0.7	60	− 5
Lower Lakes	51.1	+ 5.9	+ 8.1	0.77	−1.60	−3.00	5.2	−0.5	67	− 3
Upper Lakes	48.9	+ 8.1	+16.5	1.03	−1.30	−2.60	5.3	−0.2	71	− 2
North Dakota	50.8	+10.1	+26.1	0.99	−0.90	−2.00	4.9	−0.4	64	− 4
Upper Mississippi Valley	58.8	+ 8.3	+13.2	1.48	−1.50	−1.90	4.7	−0.5	63	− 5
Missouri Valley	58.6	+ 8.2	+ 9.7	2.45	−0.40	+1.40	4.6	−1.0	67	+ 2
Northern slope	51.3	+ 8.5	+14.3	2.10	+0.50	−0.20	5.2	+0.1	62	+ 4
Middle slope	57.8	+ 4.1	+ 3.4	3.71	+1.50	+3.00	5.6	+1.0	67	+10
Southern slope	61.6	− 0.8	− 7.3	5.64	+4.00	+4.70	5.5	+0.8	67	+12
Southern Plateau	57.0	− 0.8	− 8.7	1.28	+0.90	+1.90	3.8	+1.0	49	+19
Middle Plateau	52.3	+ 3.4	+ 2.4	1.93	+0.80	+0.30	5.7	+1.2	56	+11
Northern Plateau	53.9	+ 5.0	+16.0	1.62	+0.20	−0.90	5.5	+0.3	55	− 2
North Pacific	51.6	+ 3.2	+13.5	2.70	−0.60	−5.30	5.3	−0.4	77	+ 6
Middle Pacific	55.1	+ 1.6	+ 5.8	1.06	−1.00	+3.50	5.8	+1.4	73	+ 1
South Pacific	59.0	+ 1.0	+ 7.9	1.31	+0.30	+3.60	6.0	+2.0	75	+ 7

Maximum wind velocities, April, 1915.

Stations.	Date.	Velocity.	Direction.	Stations.	Date.	Velocity.	Direction.
		Mi./hr.				Mi./hr.	
Block Island, R. I.	3	65	ne.	North Head, Wash.	30	54	nw.
Do	4	56	n.	Pittsburgh, Pa.	11	53	w.
Buffalo, N. Y.	10	52	sw.	Point Reyes Light, Cal.	3	60	nw.
Columbus, Ohio	11	50	w.	Do	4	75	nw.
Corpus Christi, Tex.	30	50	se.	Do	5	62	nw.
Duluth, Minn.	29	52	w.	Do	7	50	nw.
Erie, Pa.	11	60	sw.	Do	12	56	nw.
Do	12	50	w.	Do	13	76	nw.
Eureka, Cal.	29	58	n.	Do	14	52	nw.
Galveston, Tex.	23	61	se.	Do	21	57	nw.
Hatteras, N. C.	3	50	ne.	Do	22	53	nw.
Houston, Tex.	23	54	se.	Do	29	110	nw.
Modena, Utah	21	56	s.	Do	30	94	nw.
Mt. Tamalpais, Cal.	4	68	nw.	Roswell, N. Mex.	16	60	se.
Do	12	50	nw.	St. Louis, Mo.	8	50	s.
Do	13	64	n.	Salt Lake City, Utah.	3	56	nw.
Do	14	62	n.	San Antonio, Tex.	18	58	se.
Do	29	64	nw.	Sand Key, Fla.	3	50	nw.
Do	30	64	nw.	Sandy Hook, N. J.	3	62	nw.
Nantucket, Mass.	3	79	ne.	Do	4	52	nw.
Do	4	54	ne.	Do	11	66	s.
New York, N. Y.	3	62	ne.	Do	27	50	w.
Do	4	60	n.	Tatoosh Island, Wash.	7	79	sw.
Do	11	70	sw.	Do	29	52	w.
Do	27	69	nw.	Toledo, Ohio	11	50	sw.
Norfolk, Va.	3	62	ne.	Trenton, N. J.	3	52	ne.
North Head, Wash.	1	54	se.	Do	20	50	w.
Do	7	58	se.				
Do	28	54	nw.				
Do	29	68	nw.				

CONDENSED CLIMATOLOGICAL SUMMARY.

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data, as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course the number of such records is smaller than the total number of stations.

Summary of temperature and precipitation, by sections, April, 1915.

Section.	Temperature (° F.).									Precipitation (in inches and hundredths).					
	Section average.	Departure from the normal.	Monthly extremes.							Section average.	Departure from the normal.	Greatest monthly.		Least monthly.	
			Station.	Highest.	Date.	Station.	Lowest.	Date.				Station.	Amount.	Station.	Amount.
Alabama	64.9	+1.9	Thomasville	96	30	Hamilton	22	4		0.57	−3.51	Tallassee	2.34	Bay Minette	0.00
Arizona	58.7	−0.7	Sentinel	99	3	2 stations	20	6		1.50	+0.94	Carr's Ranch	4.76	McNeal	0.06
Arkansas	64.3	+3.3	Brinkley	96	28	Dutton	19	3		2.96	−1.39	Hot Springs	7.53	Pine Bluff	0.67
California	56.0	−1.0	2 stations	99	11†	Tamarack	5	25		1.85	+0.06	Nellie	9.94	3 stations	T.
Colorado	46.9	+3.2	Sedgwick	90	1	Buena Vista	0	10		3.06	+1.45	Julesburg	8.44	Blue Valley	0.22
Florida	67.3	−2.0	Wausau	97	30	Newport	31	4		1.25	−1.28	Lynne (near)	3.21	Molino	0.00
Georgia	64.8	+1.6	Statesboro	96	30	2 stations	25	1†		0.65	−2.90	Louisville	2.62	Hawkinsville	0.06
Hawaii (March)	68.9	......	Mahukona, Hawaii	90	26	2 stations	47	23†		4.76	......	Warakamei, Maui	10.70	2 stations	0.12
Idaho	51.3	+5.0	Guffey	95	20	2 stations	18	2†		1.44	+0.21	Castle Creek	3.47	Geneva	0.22
Illinois	58.8	+6.6	Equality	92	28	Lanark	18	3		1.35	−1.99	Hillsboro	4.48	Fairfield	T.
Indiana	57.3	+5.5	Madison	94	25	3 stations	18	4		1.58	−1.78	Greensburg	4.32	Mount Vernon	0.28
Iowa	57.2	+8.5	Logan	95	28	Rock Rapids	18	1		1.41	−1.45	Whitten	4.02	2 stations	0.05
Kansas	59.0	+4.6	2 stations	94	28	2 stations	21	1†		3.76	+1.31	Independence	8.03	Oskaloosa	1.36
Kentucky	60.1	+4.2	Beattyville	96	25	Beattyville	17	4		0.96	−3.11	Catlettsburg	1.84	Williamsburg	0.50
Louisiana	67.1	−0.3	Angola	101	29	Robeline	26	3		1.45	−2.76	Shreveport	6.42	9 stations	0.00
Maryland & Delaware	57.0	+4.5	Yarrow, Md.	100	27	Deer Park, Md.	10	2		1.66	−1.50	Wilmington, Del.	3.15	Western Port, Md.	0.48
Michigan	49.5	+7.1	Seney	96	26	2 stations	3	3		1.05	−1.25	Cassopolis	2.63	Midland	0.32
Minnesota	52.4	+9.4	Campbell	88	22	Warroad	11	2		1.58	−0.53	Pipestone	2.86	Virginia	0.43
Mississippi	65.1	+0.8	Greenwood	97	29	Porterville	26	4		1.15	−3.75	Jackson	2.67	Pascagoula	T.
Missouri	61.9	+6.5	Maryville	96	28	Goodland	18	1		2.03	−1.82	Hermann	4.27	2 stations	0.90
Montana	50.9	+9.0	Foster	91	28	Glentana	13	13		0.84	−0.21	2 stations	2.60	2 stations	0.00
Nebraska	55.2	+5.9	4 stations	94	17†	Dumas	3	1		3.28	+0.86	Paxton	9.06	Walthill	0.60
Nevada	50.4	+2.6	Logan	92	19	Austin	15	30		1.64	+0.81	Austin	4.54	Gardnerville	0.18
New England	48.0	+4.4	Bridgeport, Conn.	93	25†	2 stations	15	3†		2.24	−0.94	Madison, Me.	4.78	Rockport, Mass.	0.60
New Jersey	54.4	+5.3	2 stations	96	25†	2 stations	20	3†		2.71	−0.78	Bergen Point	4.13	Pleasantville	1.28
New Mexico	52.9	+0.1	Artesia	93	27	Elizabethtown	13	10		3.38	+1.95	Texico (near)	10.13	Columbus	T.
New York	49.7	+6.1	Bedford	96	27	Lake Placid Club	3	3		1.61	−1.22	Bedford	3.95	Westfield	0.09
North Carolina	59.5	+2.1	Tarboro	97	26	Banners Elk	15	1		1.90	−1.79	Lumberton	4.23	Chimney Rock	0.28
North Dakota	50.2	+8.8	Forman	99	15	Minot	5	1		1.06	−0.41	Pembina	2.23	Steele	0.29
Ohio	54.8	+5.2	4 stations	96	1†	Peebles	12	1		1.42	−1.80	Toboso	3.16	2 stations	0.35
Oklahoma	62.5	+3.0	Newkirk	95	28	Healdton	19	3		6.26	+3.06	Lawtonka Lake	10.02	Wyandotte	2.02
Oregon	51.7	+4.0	2 stations	90	18†	Whitaker	11	9†		1.79	−0.41	Musick	8.26	Big Basin	0.07
Pennsylvania	53.9	+5.5	Punxsutawney	98	26	Warren	15	4		1.92	−1.52	Gouldsboro	4.41	Mosgrove	0.46
Porto Rico	76.1	+0.8	Guanica Centrale	100	5†	San Sebastian	50	1†		8.58	+3.43	RioGrande(ElVerde)	26.21	Josefa	0.60
South Carolina	63.1	+0.8	2 stations	96	26†	Liberty	25	4		1.47	−1.33	Kingstree	5.34	Clemson College	T.
South Dakota	53.2	+7.7	Fairfax	96	19	Kennebec	3	1		2.42	+0.20	Oelrichs	4.95	Rosebud	0.48
Tennessee	61.5	+3.1	2 stations	95	26†	Erasmus	15	1		1.13	−3.11	Trenton	2.78	Byrdstown	0.13
Texas	65.8	−0.2	Llano Grande	97	27†	Albany	22	3		5.82	+2.97	Austin	19.82	El Paso	0.20
Utah	51.7	+3.7	Iosepa	88	12	Scofield	15	10		1.72	+0.52	Pine Valley	5.00	Kelton	0.11
Virginia	58.0	+4.2	Lincoln	100	26	Burkes Garden	16	2		1.42	−1.98	Burkes Garden	2.65	Woodstock	0.30
Washington	52.2	+3.5	Hanford	88	19	Republic	14	14		2.56	+0.11	Quiniault	12.87	Eltopia	0.12
West Virginia	55.7	+3.7	Romney	101	26	Parsons	10	1†		1.93	−1.72	Beckley	5.69	Upper Tract	0.10
Wisconsin	52.2	+8.6	Pine River	90	28	Koepenick	4	1		0.86	−1.73	Glen Flora	1.93	3 stations	T.
Wyoming	46.0	+6.4	Lovell	85	29	Afton	2	1		1.67	+0.52	Fort Laramie	4.90	Hyattville	0.06

† Other dates also.

DESCRIPTION OF TABLES AND CHARTS.

Table I gives the data ordinarily needed for climatological studies for about 158 Weather Bureau stations making simultaneous observations at 8 a. m. and 8 p. m., daily, 75th meridian time and for about 41 others making only one observation. The altitudes of the instruments above ground are also given.

Table II gives a record of precipitation, the intensity of which at some period of the storm's continuance equaled or exceeded the following rates:

Duration (minutes)	5	10	15	20	25	30	35	40	45	50	60
Rates per hour (inches)	3.00	1.80	1.40	1.20	1.08	1.00	0.94	0.90	0.87	0.84	0.80

It is impracticable to make this table sufficiently wide to accommodate on one line the record of accumulated falls that continue at an excessive rate for several hours. In this case *the record is broken at the end of each 50 minutes*, the accumulated amounts being recorded on successive lines until the excessive rate ends.

In cases where no storm of sufficient intensity to entitle it to a place in the full table has occurred, the greatest precipitation of any single storm has been given, also the greatest hourly fall during that storm.

Table III gives, for about 30 stations of the Canadian Meteorological Service, the means of pressure and temperature, total precipitation and depth of snowfall, and the respective departures from normal values except in the case of snowfall.

Chart I.—Hydrographs for several of the principal rivers of the United States.

Chart II.—Tracks of centers of high areas; and

Chart III.—Tracks of centers of low areas. The roman numerals show the chronological order of the centers. The figures within the circles show the days of the month; the letters *a* and *p* indicate, respectively, the observations at 8 a. m. and 8 p. m., 75th meridian time. Within each circle is also given (Chart II) the last three figures of the highest barometric reading and (Chart III) the lowest reading reported at or near the center at that time, and in both cases as reduced to sea level and standard gravity.

Chart IV.—Temperature departures. This chart presents the departures of the monthly mean temperatures from the monthly normals. The normals used in computing the departures were computed for a period of 33 years (1873 to 1905) and are published in Weather Bureau Bulletin "R," Washington, 1908. Stations whose records were too short to justify the preparation of normals in 1908 have been provided with normals as adequate records became available and all have been reduced to the 33-year interval 1873–1905. The shaded portions of the chart indicate areas of positive departures and unshaded portions indicate areas of negative departures. Generalized lines connect places having approximately equal departures of like sign. This chart of monthly temperature departures in the United States was first published in the MONTHLY WEATHER REVIEW for July, 1909.

Chart V.—Total precipitation. The scale of shades showing the depth is given on the chart. Where the monthly amounts are too small to justify shading, and over sections of the country where stations are too widely separated or the topography is too diversified to warrant reasonable accuracy in shading, the actual depths are given for a limited number of representative stations. Amounts less than 0.005 inch are indicated by the letter T, and no precipitation by 0.

Chart VI.—Percentage of clear sky between sunrise and sunset. The average cloudiness at each Weather Bureau station is determined by numerous personal observations between sunrise and sunset. The difference between the observed cloudiness and 100 is assumed to represent the percentage of clear sky, and the values thus obtained are the basis of this chart. The chart does not relate to the nighttime.

Chart VII.—Isobars and isotherms at sea level and prevailing wind directions. The pressures have been reduced to sea level and standard gravity by the method described by Prof. Frank H. Bigelow on pages 13–16 of the REVIEW for January, 1902. The pressures have also been reduced to the mean of the 24 hours by the application of a suitable correction to the mean of the 8 a. m. and 8 p. m. readings at stations taking two observations daily, and to the 8 a. m. or the 8 p. m. observation, respectively, at stations taking but a single observation. The diurnal corrections so applied will be found in the Annual Report of the Chief of the Weather Bureau, 1900–1901, volume 2, Table 27, pages 140–164.

The isotherms on the sea-level plane have been constructed by means of the data summarized in chapter 8 of volume 2, of the annual report just mentioned. The correction t_0-t, or temperature on the sea-level plane minus the station temperature as given by Table 48 of that report, is added to the observed surface temperature to obtain the adopted sea-level temperature.

The prevailing wind directions are determined from hourly observations at the great majority of the stations; a few stations having no self-recording wind direction apparatus determine the prevailing direction from the daily or twice-daily observations only.

Chart VIII.—Total snowfall. This is based on the reports from regular and cooperative observers and shows the depth in inches and tenths of the snowfall during the month. In general, the depth is shown by lines inclosing areas of equal snowfall, but in special cases figures are also given. Chart VIII is published only when the general snow cover is sufficiently extensive to justify its preparation.

TABLE I.—*Climatological data for United States Weather Bureau stations, April, 1915.*

Districts and stations.	Elevation of instruments.			Pressure in inches.			Temperature of the air, in degrees Fahrenheit.													Precipitation, inches.			Wind.									
	Barometer above sea level, feet.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity, per cent.	Total.	Departure from normal.	Days with 0.01 or more.	Total movement, miles.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.
New England.							**47.8**	**+ 4.2**										**73**	**1.99**	**− 1.1**										**6.0**		
Eastport	76	67	85	29.94	30.03	+0.10	39.6	+ 1.3	67	20	45	27	4	34	33	37	34	80	3.58	+ 0.6	17	7,952	s.	42	ne.	3	3	10	17	7.6	11.6	....
Greenville	1,070	6	....	28.84	30.02	......	40.8	......	72	26	50	15	3	31	38	....	....	....	3.49	......	11	......	......	....	......	....	....	....	....	....	3.0	....
Portland, Me.	103	82	117	29.92	30.04	+ .08	45.8	+ 2.8	68	26	54	29	3	38	30	40	34	68	3.43	+ 0.3	12	7,242	n.	33	ne.	4	7	5	18	6.8	8.6	....
Concord	288	70	79	29.71	30.03	+ .04	48.4	+ 4.6	85	26	60	24	5	37	45	....	....	....	2.62	− 0.2	8	4,399	nw.	28	ne.	3	11	10	9	4.9	3.3	....
Burlington	404	11	48	29.59	30.03	+ .04	48.3	+ 7.6	82	26	58	24	3	38	35	....	....	....	0.73	− 1.1	9	8,297	n.	39	s.	28	7	10	13	5.8	0.9	....
Northfield	876	12	60	29.08	30.04	+ .05	45.5	+ 5.3	82	26	58	19	5	33	39	40	35	71	1.06	− 1.0	11	6,246	s.	34	sw.	12	9	7	14	6.3	1.4	....
Boston	125	115	188	29.88	30.02	+ .05	50.8	+ 5.5	84	26	59	30	3	42	42	44	39	70	1.86	− 1.7	6	7,699	nw.	36	ne.	3	10	8	12	5.8	6.1	....
Nantucket	12	14	90	30.00	30.01	+ .04	45.5	+ 1.3	74	20	52	34	4	39	32	42	40	87	1.72	− 0.9	10	11,800	sw.	79	ne.	3	10	10	10	6.0	T.	....
Block Island	26	11	46	29.98	30.01	+ .03	47.0	+ 3.2	78	27	53	30	4	41	34	44	42	88	1.83	− 1.8	10	11,569	sw.	65	ne.	3	10	8	12	5.7	2.6	....
Narragansett	....	9	....	......	......	......	47.4	......	86	27	56	29	5	39	38	....	....	....	1.54	......	9	......	s.	....	......	....	15	5	10	7.5	....	....
Providence	160	215	251	29.84	30.02	+ .04	50.4	+ 3.8	86	27	60	30	3	41	43	43	37	68	1.58	− 2.2	7	9,655	nw.	46	ne.	3	10	14	6	5.2	4.6	....
Hartford	159	122	140	29.85	30.03	+ .04	52.3	+ 5.6	90	27	63	28	3	42	41	44	37	62	1.58	− 2.0	7	6,118	s.	31	sw.	12	8	14	8	5.4	7.5	....
New Haven	106	117	155	29.92	30.03	+ .04	51.8	+ 5.4	91	27	62	29	3	42	40	44	37	65	1.86	− 1.7	9	6,824	n.	42	n.	3	9	12	9	5.2	8.0	....
Middle Atlantic States.							**55.7**	**+ 5.2**										**65**	**1.90**	**− 1.2**										**4.7**		
Albany	97	102	115	29.92	30.03	+ .03	52.7	+ 6.9	91	27	63	28	5	42	35	46	40	67	2.15	− 0.2	7	6,627	s.	31	s.	22	12	8	10	4.9	1.3	....
Binghamton	871	10	69	29.12	30.06	+ .04	51.4	+ 7.0	88	27	63	25	5	40	39	....	....	....	1.75	− 0.5	8	2,631	nw.	25	nw.	27	10	8	12	5.7	T.	....
New York	314	414	454	29.69	30.02	+ .02	53.4	+ 5.3	91	27	63	28	3	44	42	45	38	62	2.10	− 1.2	11	11,959	nw.	70	sw.	11	7	14	9	5.7	10.2	....
Harrisburg	374	94	104	29.66	30.06	+ .04	57.0	+ 6.3	93	25	68	32	2	46	34	47	39	57	2.13	− 0.4	8	4,665	n.	42	sw.	10	12	10	8	4.7	T.	....
Philadelphia	117	123	190	29.93	30.05	+ .04	57.3	+ 6.5	93	27	68	30	3	47	39	49	42	61	4.23	+ 1.3	11	7,901	nw.	46	ne.	3	11	14	5	4.9	19.4	....
Reading	325	81	98	29.70	30.06	......	56.4	......	94	25	68	30	3	45	40	47	39	59	2.61	− 0.6	10	5,196	nw.	32	nw.	27	10	10	10	5.6	4.8	....
Scranton	805	111	119	29.19	30.06	+ .05	53.9	+ 6.8	88	25	64	29	3	43	36	46	41	67	1.65	− 1.0	8	4,807	nw.	32	nw.	27	9	12	9	5.5	T.	....
Atlantic City	52	37	48	29.99	30.05	+ .05	51.8	+ 4.2	85	27	60	30	3	44	33	46	42	76	2.17	− 0.8	9	6,016	sw.	49	ne.	3	7	13	10	6.0	6.0	....
Cape May	18	13	49	30.05	30.07	+ .08	53.0	+ 4.6	83	27	61	31	3	45	25	....	....	....	1.90	− 1.1	8	6,488	s.	32	nw.	4	11	15	4	4.9	8.8	....
Sandy Hook	22	10	57	30.02	30.04	......	51.8	......	89	27	60	31	3	44	40	49	48	93	2.00	......	10	10,643	nw.	66	s.	11	9	12	9	5.4	5.5	....
Trenton	190	159	183	29.83	30.04	......	54.9	......	93	27	66	29	3	44	40	47	41	66	3.04	− 0.2	10	8,343	nw.	52	ne.	3	10	13	7	5.2	16.0	....
Baltimore	123	100	113	29.93	30.06	+ .05	59.2	+ 6.2	89	25	69	32	3	49	30	50	41	57	1.37	− 1.9	8	5,722	n.	35	n.	20	15	10	5	4.1	4.5	....
Washington	112	62	85	29.93	30.05	+ .03	59.4	+ 6.3	95	27	72	32	3	47	36	49	41	56	0.90	− 2.4	7	5,399	nw.	29	ne.	3	11	13	6	4.4	3.5	....
Lynchburg	681	153	188	29.31	30.05	+ .03	59.8	+ 4.2	93	27	73	30	2	46	40	51	45	64	0.87	− 2.3	4	5,534	n.	35	ne.	2	13	14	3	4.1	2.3	....
Norfolk	91	170	205	29.97	30.06	+ .05	60.2	+ 4.2	93	27	70	32	3	50	33	51	45	65	0.91	− 2.9	4	10,493	sw.	62	ne.	3	19	6	5	3.3	T.	....
Richmond	144	11	52	29.91	30.07	+ .07	59.9	+ 2.7	96	27	72	31	1	48	37	51	44	62	1.68	− 1.8	5	6,202	sw.	39	sw.	11	17	11	2	3.1	10.0	....
Wytheville	2,293	40	47	27.71	30.09	+ .06	53.5	+ 1.5	87	27	67	24	2	40	38	46	40	67	1.02	− 2.6	9	3,542	w.	26	nw.	4	18	6	6	3.2	0.5	....
South Atlantic States.							**62.7**	**+ 1.4**										**69**	**1.59**	**− 1.8**										**3.4**		
Asheville	2,255	70	84	27.74	30.10	+ .07	56.4	+ 2.5	86	27	69	25	4	44	37	47	40	61	1.09	− 3.0	9	5,138	nw.	36	e.	21	16	9	5	3.8	0.3	....
Charlotte	773	68	76	29.24	30.08	+ .05	61.8	+ 2.6	92	26	74	31	4	50	32	51	43	57	0.63	− 2.8	5	4,956	ne.	34	w.	11	15	10	5	4.0	0.6	....
Hatteras	11	12	50	30.05	30.06	+ .05	59.2	+ 1.2	79	28	65	38	3	53	22	54	51	80	3.99	− 0.4	4	10,956	sw.	50	ne.	3	11	13	6	4.5	....	....
Manteo	12	4	46	......	......	......	58.2	......	92	27	69	30	5	47	....	....	....	....	3.19	− 1.4	5	......	sw.	48	ne.	3	24	3	3	....	....	....
Raleigh	376	103	110	29.67	30.07	+ .04	61.8	+ 2.8	92	26	73	31	4	50	33	52	44	50	2.26	− 1.2	4	5,874	sw.	35	n.	7	19	8	3	3.2	10.0	....
Wilmington	78	81	91	30.01	30.09	+ .06	61.8	+ 1.4	86	28	72	33	1	52	32	54	51	76	1.85	− 1.0	4	5,984	sw.	42	ne.	2	17	11	2	3.1	T.	....
Charleston	48	11	92	30.04	30.09	+ .06	63.3	− 0.5	84	30	71	37	1	56	24	57	53	77	1.13	− 1.9	4	7,087	s.	40	ne.	2	23	4	3	2.3	....	....
Columbia, S. C.	351	41	57	29.70	30.08	+ .05	64.8	+ 2.0	90	30	77	32	4	53	31	53	46	59	1.22	− 1.6	3	4,918	s.	33	sw.	11	21	5	4	3.2	T.	....
Augusta	180	89	97	29.89	30.08	+ .05	65.8	+ 2.6	90	30	78	33	4	54	34	55	49	61	0.65	− 2.8	2	4,084	se.	24	sw.	11	19	7	4	3.2	....	....
Savannah	65	150	194	30.02	30.09	+. 06	64.8	+ 0.1	91	30	74	37	2	56	28	58	55	82	0.98	− 2.0	3	8,551	s.	34	n.	2	20	6	4	3.0	....	....
Jacksonville	43	96	129	30.04	30.09	+ .05	66.9	− 0.7	89	30	76	41	4	58	27	60	57	81	0.49	− 2.2	2	......	se.	....	......	....	19	8	3	3.2	....	....
Florida Peninsula.							**70.1**	**− 3.3**										**72**	**1.34**	**− 0.6**										**3.6**		
Key West	22	10	64	30.01	30.03	+0.01	72.2	− 3.3	82	26	77	56	3	67	14	65	61	71	1.52	+ 0.2	4	9,189	e.	46	nw.	3	21	6	3	2.7	....	....
Miami	25	71	79	30.02	30.05	+ .03	69.5	− 4.7	81	18	75	45	4	64	22	63	59	70	1.32	− 1.3	6	8,660	e.	32	nw.	3	7	16	7	5.3	....	....
Sand Key	23	39	72	29.98	30.01	− .01	71.0	......	82	19	73	58	4	69	13	66	63	75	1.82	......	6	13,590	e.	50	nw.	3	20	7	3	3.0	....	....
Tampa	35	79	96	30.04	30.07	+ .01	68.6	− 2.0	86	21	78	43	5	59	28	60	56	70	1.18	− 0.7	5	5,181	ne.	23	ne.	23	20	7	3	3.3	....	....
Titusville	44	6	....	......	......	......	......	......	....	....	....	....	....	....	....	....	....	....	......	......	....	......	......	....	......	....	....	....	....	....	....	....
East Gulf States.							**66.1**	**+ 1.5**										**65**	**0.54**	**− 3.5**										**3.6**		
Atlanta	1,174	190	216	28.85	30.09	+ .06	64.4	+ 3.3	88	27	75	31	4	54	28	55	48	61	0.35	− 3.3	4	7,332	nw.	34	nw.	3	21	5	4	3.2	....	....
Macon	370	78	87	29.68	30.07	+ .04	65.6	+ 2.5	89	30	78	34	1	53	35	56	49	60	0.32	− 3.1	2	3,696	s.	28	s.	28	21	7	2	2.4	....	....
Thomasville	273	8	57	29.78	30.08	+ .05	66.4	− 0.3	93	30	80	34	4	53	35	56	52	71	0.57	− 3.1	4	3,565	e.	15	sw.	5	18	10	2	3.1	....	....
Pensacola	56	140	182	30.03	30.09	+ .07	66.0	− 1.7	85	17	73	40	1	59	23	59	55	75	0.06	− 3.1	2	8,349	se.	36	se.	23	11	13	6	4.5	....	....
Anniston	741	9	57	29.32	30.11	+ .08	64.4	+ 4.0	89	29	78	29	4	51	37	....	....	....	0.07	− 3.6	2	3,765	n.	23	w.	30	22	6	2	2.5	....	....
Birmingham	700	11	48	29.34	30.10	+ .08	66.0	+ 2.5	89	29	78	32	4	54	32	53	44	53	1.05	− 2.6	4	4,528	n.	35	s.	21	18	9	3	3.4	....	....
Mobile	57	125	161	30.02	30.08	+ .06	66.5	+ 0.5	89	29	75	39	4	58	28	58	53	70	0.14	− 4.2	2	6,628	s.	28	nw.	3	15	11	4	3.9	....	....
Montgomery	223	100	112	29.84	30.09	+ .06	67.3	+ 2.1	90	30	79	37	4	56	30	55	46	54	0.38	− 3.9	4	4,295	s.	30	w.	30	21	6	3	2.6	....	....
Meridian	375	85	93	29.68	30.08	+ .06	65.0	+ 0.9	90	29	78	30	4	52	36	57	52	68	0.79	− 4.2	4	3,522	s.	22	nw.	28	14	9	7	4.5	....	....
V cksburg	247	65	74	29.81	30.09	+ .09	67.0	+ 1.8	90	29	77	40	4	57	29	56	49	62	2.21	− 3.0	4	4,961	se.	34	e.	29	7	12	11	5.5	....	....
New Orleans	51	76	84	30.02	30.07	+ .07	68.8	+ 0.9	90	29	78	42	3	60	25	60	57	73	0.04	− 4.9	2	5,054	se.	23	nw.	2	12	15	3	3.8	....	....
West Gulf States.							**66.3**	**+ 0.5**										**75**	**6.23**	**+ 2.7**										**6.4**		
Shreveport	249	77	93	29.78	30.05	+ .08	67.3	+ 1.5	88	29	77	35	3	58	28	58	51	65	6.42	+ 1.8	10	5,636	se.	30	s.	9	9	6	15	6.0	....	....
Bentonville	1,303	11	44	28.66	30.02	+ .06	62.0	+ 5.1	85	28	72	26	3	52	33	....	....	....	3.21	− 0.7	10	3,660	s.	26	sw.	30	8	7	15	5.9	....	....
Fort Smith	457	79	94	29.53	30.01	+ .05	65.3	+ 3.6	90	29	75	32	3	55	32	56	50	65	4.77	+ 0.9	11	5,782	e.	37	se.	22	6	9	15	6.4	....	....
Little Rock	357	139	147	29.68	30.05	+ .07	65.5	+ 2.8	86	29	75	36	3	56	27	59	56	76	2.92	− 1.6	6	6,314	s.	33	w.	30	12	10	8	4.7	T.	....
Brownsville	57	3	40	......	......	......	71.4	......	86	29	79	39	2	64	31	....	....	....	1.04	......	3	......	s.	36	......	....	....	....	....	....	....	....
Corpus Christi	20	69	77	29.97	29.99	+ .04	68.4	− 2.5	81	11	72	44	2	65	21	65	64	90	1.58	− 0.2	3	11,506	e.	50	se.	30	2	10	18	7.4	....	....
Dallas	512	109	117	29.47	30.01	......	66.4	......	86	29	75	38	3	58	29	....	....	....	3.86	......	11	7,171	se.	39	s.	4	4	11	15	6.8	....	....
Fort Worth	670	106	114	29.26	29.97	+ .03	66.2	+ 0.9	86	29	76	31	3	57	35	58	52	68	4.98	+ 2.3	11	7,997	s.	36	s.	4	3	8	19	7.2	....	....
Galveston	54	106	114	29.99	30.06	+ .09	66.1	− 2.6	77	29	70	44	2	63	13	63	61	89	3.37	+ 0.2	6	9,035	se.	36	s.	23	7	16	7	5.6	....	....
Houston	138	111	121	29.88	30.03	......	67.8	− 1.8	86	29	76	40	3	60	27	....	....	....	1.90	......	7	7,416	se.	54	se.	23	5	9	16	6.4	....	....
Palestine	510	64	72	29.48	30.02	+ .06	67.0	+ 1.1	87	29	76	38	3	58	27	59	55	70	7.22	+ 3.1	11	5,904	s.	26	s.	22	7	4	19	6.9	....	....
San Antonio	701	109	132	29.28	29.98	+ .05	67.5	− 1.5	85	21	76	39	2	59	31	61	58	79	11.64	+ 8.7	10	6,664	s.	58	se.	18	6	11	13	6.2	....	....
Taylor	582	55	63	29.42	30.03	+ .08	66.0	− 1.5	84	29	75	34	3	57	32	....	....	....	16.18	+12.2	14	7,248	se.	34	sw.	22	4	9	17	6.8	....	....

TABLE I.—*Climatological data for United States Weather Bureau stations, April, 1915*—Continued.

Districts and stations.	Elevation of instruments: Barometer above sea level, feet.	Thermometer above ground.	Anemometer above ground.	Pressure in inches: Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Temperature of the air, in degrees Fahrenheit: Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity, per cent.	Precipitation, inches: Total.	Departure from normal.	Days with 0.01 or more.	Wind: Total movement, miles.	Prevailing direction.	Maximum velocity: Miles per hour.	Direction.	Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.
Ohio Valley and Tennessee.							**59.5**	**+4.8**										**60**	**1.20**	**−2.4**										**4.6**		
Chattanooga	762	189	213	29.29	30.10	+0.07	64.7	+4.7	88	26	76	32	4	53	35	52	42	50	1.72	−2.7	3	5,705	w.	36	nw.	11	12	14	4	4.3	...	...
Knoxville	996	93	100	29.03	30.08	+.05	62.0	+4.6	89	27	74	27	4	49	36	52	44	58	1.45	−3.2	5	3,566	ne.	30	sw.	10	12	10	8	4.6	...	...
Memphis	399	76	97	29.67	30.10	+.10	65.9	+4.1	87	29	75	33	1	57	26	56	49	60	1.67	−3.2	6	6,146	s.	29	sw.	5	17	5	8	4.0	...	...
Nashville	546	168	191	29.51	30.09	+.08	63.5	+4.4	88	29	75	31	4	52	37	53	44	56	0.72	−3.6	6	6,579	s.	30	n.	3	14	12	4	3.9	...	...
Lexington	989	75	102	29.02	30.09	+.07	59.2	+5.5	88	25	70	26	1	48	32	...	...	...	0.65	−2.7	6	7,336	s.	40	sw.	10	15	12	3	3.8	...	...
Louisville	525	219	255	29.51	30.09	+.08	61.6	+5.4	89	26	72	30	1	51	32	52	45	59	1.02	−3.0	6	8,114	s.	48	sw.	10	15	8	7	4.5	...	...
Evansville	431	72	82	29.60	30.07	+.07	61.9	+5.5	89	25	72	30	3	51	33	52	41	57	0.40	−3.1	4	4,166	s.	23	s.	10	16	8	6	4.1	...	...
Indianapolis	822	154	164	29.19	30.08	+.08	58.0	+5.6	87	25	68	29	4	48	30	49	41	58	0.99	−2.5	10	6,906	sw.	38	sw.	11	12	10	8	4.8	T.	...
Terre Haute	575	96	129	29.44	30.06	...	59.7	...	86	25	70	28	3	49	31	50	43	61	1.23	...	7	6,874	s.	28	nw.	11	7	20	3	4.9	...	...
Cincinnati	628	11	51	29.40	30.08	+.07	58.4	+4.1	89	26	69	23	1	48	34	50	44	66	0.84	−2.1	8	5,299	ne.	36	sw.	10	11	14	5	4.5	...	...
Columbus	824	173	222	29.21	30.09	+.07	56.3	+5.3	90	25	67	22	1	46	33	48	41	62	0.95	−1.9	9	7,687	sw.	50	w.	11	10	11	9	5.3	T.	...
Dayton	899	181	216	29.10	30.06	...	57.2	+5.5	89	25	68	25	1	47	31	48	42	63	0.83	−2.1	8	6,957	sw.	43	sw.	10	15	12	3	3.7	T.	...
Pittsburgh	842	353	410	29.16	30.07	+.05	55.5	+4.5	87	26	66	26	4	45	37	46	38	56	1.27	−1.6	12	7,718	nw.	53	w.	11	10	6	14	5.4	T.	...
Elkins	1,940	41	50	28.04	30.11	+.08	51.8	+3.1	88	26	66	18	2	38	48	44	38	68	2.28	−1.0	13	2,809	w.	26	w.	10	7	12	11	5.8	T.	...
Parkersburg	638	77	84	29.44	30.10	+.07	57.3	+4.3	91	25	69	22	2	46	39	48	41	60	2.02	−0.9	9	3,981	n.	37	nw.	20	13	6	11	4.9	...	...
Lower Lake Region.							**51.1**	**+5.9**										**67**	**0.77**	**−1.6**										**5.2**		
Buffalo	767	247	280	29.22	30.06	+.05	46.8	+4.5	76	26	55	27	4	38	32	42	39	76	0.59	−1.9	10	11,318	sw.	52	sw.	10	8	11	11	5.6	T.	...
Canton	448	10	61	29.55	30.03	...	50.0	+7.5	84	25	60	27	4	40	31	...	...	...	1.30	−1.0	11	7,003	sw.	43	w.	12	13	9	8	4.5	0.6	...
Oswego	335	76	91	29.67	30.04	+.03	47.6	+4.4	81	28	55	28	3	40	32	43	39	75	0.61	−1.6	8	5,690	w.	31	ne.	3	10	8	12	5.2	T.	...
Rochester	523	97	113	29.49	30.06	+.05	51.4	+7.5	86	25	60	29	4	43	32	44	38	64	1.06	−1.4	9	6,020	w.	40	sw.	10	9	9	12	5.7	0.5	...
Syracuse	597	97	113	29.41	30.06	+.05	51.0	+6.6	84	25	60	26	3	42	28	44	37	62	0.79	−1.5	11	7,770	nw.	36	w.	11	11	8	11	5.8	0.8	...
Erie	714	130	166	29.28	30.06	+.04	50.8	+5.1	81	24	59	26	4	43	31	44	38	66	0.74	−1.7	11	8,795	sw.	60	sw.	11	10	13	7	5.4	0.5	...
Cleveland	762	190	201	29.25	30.08	+.06	51.8	+5.8	84	26	59	28	3	44	31	45	39	66	0.65	−1.7	4	8,347	ne.	48	w.	11	11	12	7	4.5	T.	...
Sandusky	629	62	103	29.38	30.07	+.05	52.8	+5.5	87	27	61	25	4	44	33	46	40	66	0.35	−2.2	8	8,454	sw.	47	w.	11	8	10	12	5.6	T.	...
Toledo	628	208	243	29.39	30.08	+.07	53.8	+6.5	89	26	63	26	3	44	33	47	41	65	0.96	−1.3	8	9,784	sw.	50	sw.	11	13	8	9	4.7	T.	...
Fort Wayne	856	113	124	29.14	30.07	...	54.2	+4.9	87	26	65	25	1	44	32	47	41	64	1.58	...	10	6,724	sw.	39	sw.	11	10	7	13	5.3	T.	...
Detroit	730	218	245	29.27	30.07	+.07	52.2	+6.7	87	25	61	25	3	43	27	45	38	63	0.66	−1.7	6	8,110	sw.	40	w.	11	15	6	9	4.9	T.	...
Upper Lake Region.							**48.9**	**+8.1**										**71**	**1.03**	**−1.3**										**5.3**		
Alpena	609	13	92	29.37	30.04	+.02	45.4	+7.4	88	24	54	21	3	36	42	40	36	76	0.90	−1.3	8	7,511	se.	36	nw.	11	9	10	11	5.6	0.2	...
Escanaba	612	54	60	29.35	30.03	+.01	43.4	+6.2	81	28	52	21	3	35	40	38	34	75	0.86	−1.2	5	6,160	s.	35	nw.	29	13	4	13	4.9	T.	...
Grand Haven	632	54	92	29.36	30.05	+.04	49.6	+5.6	84	26	58	24	3	41	29	43	38	70	0.67	−1.8	8	8,569	s.	36	s.	18	15	8	7	3.9	T.	...
Grand Rapids	707	70	87	29.28	30.06	+.04	53.8	+7.6	88	26	64	26	3	44	29	46	39	62	0.85	−1.6	10	4,392	sw.	26	w.	29	8	11	11	5.9	0.4	...
Houghton	684	62	72	29.27	30.00	−.02	45.8	+8.9	82	25	56	19	3	35	42	...	...	...	1.62	−0.4	10	5,903	se.	37	nw.	29	8	10	12	5.7	1.5	...
Lansing	878	11	62	29.11	30.06	...	51.6	+6.0	88	26	63	21	3	40	35	46	42	75	1.00	−1.5	9	4,667	sw.	28	nw.	11	7	11	12	5.7	T.	...
Ludington	637	60	66	29.34	30.04	...	47.2	...	77	26	55	23	3	39	26	43	39	75	0.91	...	8	7,754	s.	31	s.	18	10	10	10	5.6	T.	...
Marquette	734	77	111	29.22	30.03	+.01	47.4	+9.9	84	25	59	20	3	36	40	42	38	73	0.99	−1.0	9	7,778	nw.	36	nw.	28	9	9	12	6.2	1.8	...
Port Huron	638	70	120	29.36	30.06	+.04	49.0	+6.8	87	26	59	21	4	39	33	43	39	71	0.76	−1.3	9	7,487	sw.	36	w.	19	11	12	7	4.9	0.1	...
Saginaw	641	48	82	29.36	30.06	...	51.6	...	88	26	62	23	4	41	31	45	40	69	1.38	−1.3	11	6,574	s.	36	nw.	11	10	12	8	5.2	T.	...
Sault Ste. Marie	614	11	61	29.34	30.05	+.02	44.2	+8.5	83	24	54	20	3	34	35	38	34	73	1.38	−0.7	12	5,765	w.	32	nw.	29	11	6	13	5.8	1.5	...
Chicago	823	140	310	29.16	30.06	+.06	56.3	+10.4	88	26	64	30	4	48	28	48	43	66	1.02	−1.9	7	8,584	s.	36	sw.	27	15	10	5	4.0	T.	...
Green Bay	617	109	144	29.34	30.01	.00	52.3	+11.6	85	26	62	26	3	42	31	44	39	66	1.33	−1.1	8	8,263	s.	40	w.	28	7	15	8	6.1	...	...
Milwaukee	681	119	133	29.29	30.04	+.05	51.3	+9.5	86	28	60	27	3	42	32	44	39	70	0.46	−2.2	6	7,000	sw.	32	sw.	27	12	11	7	4.8	T.	...
Duluth	1,133	11	47	28.78	30.01	.00	45.4	+7.0	81	18	55	24	2	36	33	41	37	77	1.23	−0.9	9	8,899	ne.	52	w.	29	12	10	8	5.0	0.1	...
North Dakota.							**50.8**	**+10.1**										**64**	**0.99**	**−0.9**										**4.9**		
Moorhead	940	8	57	28.95	29.97	−.02	51.6	+10.2	83	21	63	22	12	40	35	45	41	74	1.15	−1.2	11	6,553	nw.	34	nw.	28	16	8	6	3.9	...	...
Bismarck	1,674	8	57	28.18	29.97	.00	51.5	+8.9	88	14	65	14	1	38	45	43	34	61	1.04	−0.8	5	8,400	nw.	41	s.	21	13	9	8	4.5	...	...
Devils Lake	1,482	11	44	28.36	29.94	−.05	48.3	+10.1	83	21	62	14	1	35	43	40	33	65	1.10	−0.9	8	8,508	s.	40	nw.	10	7	12	11	5.8	T.	...
Williston	1,872	40	47	27.94	29.92	−.04	51.6	+11.1	84	13	65	18	1	38	40	42	32	54	0.68	−0.6	4	6,693	se.	40	nw.	10	10	12	8	5.3	...	...
Upper Mississippi Valley.							**5.88**	**+8.3**										**63**	**1.48**	**−1.5**										**4.7**		
Minneapolis	918	10	208	28.96	29.94	...	56.0	...	82	19	66	29	2	46	30	...	...	...	1.87	−0.6	11	8,794	s.	39	nw.	11	7	9	14	6.1	...	...
St. Paul	837	201	236	29.08	29.99	.00	55.8	+10.1	82	19	65	30	3	46	29	...	...	...	2.75	+0.4	12	9,281	s.	46	sw.	24	6	18	6	5.2	T.	...
La Crosse	714	11	48	29.24	30.01	+.03	56.8	+9.5	84	28	68	24	3	46	32	...	...	...	0.86	−1.4	10	4,373	se.	30	w.	10	7	13	10	5.9	T.	...
Madison	974	70	78	28.98	30.04	+.05	54.0	+9.5	84	28	64	25	3	44	32	46	38	61	0.92	−1.5	6	7,310	s.	31	sw.	9	10	9	11	5.8	0.3	...
Charles City	1,015	10	49	28.92	30.00	+.02	55.4	+9.1	82	28	67	26	3	44	34	49	45	77	2.75	−0.1	8	5,681	se.	32	sw.	10	12	13	5	4.6	...	...
Davenport	606	71	79	29.36	30.02	+.04	58.5	+8.3	86	28	70	26	3	47	32	49	42	61	0.62	−2.3	9	5,898	e.	26	nw.	11	15	13	2	3.6	T.	...
Des Moines	861	84	97	29.08	29.98	+.01	59.4	+8.8	86	28	70	29	3	48	30	51	44	64	1.36	−1.6	10	5,959	s.	30	sw.	23	12	9	9	5.0	T.	...
Dubuque	698	81	96	29.28	30.04	+.06	57.7	+8.8	87	28	68	24	3	47	30	48	41	59	0.38	−2.5	10	5,244	s.	26	nw.	11	9	11	10	5.4	T.	...
Keokuk	614	64	78	29.35	30.02	+.04	60.4	+8.4	84	19	71	28	3	50	32	52	46	64	1.27	−2.1	6	3,082	se.	26	sw.	27	17	10	3	3.5	...	...
Cairo	356	87	93	29.67	30.05	+.06	63.6	+5.1	87	28	73	30	1	54	32	54	47	60	1.01	−2.6	5	6,470	s.	30	sw.	10	14	9	7	4.1	...	...
Peoria	609	11	45	29.39	30.06	+.07	58.8	+7.9	85	25	70	22	3	47	33	50	44	65	1.60	−1.7	8	5,510	s.	29	w.	27	13	10	7	4.2	...	...
Springfield, Ill	644	10	91	29.36	30.04	+.06	60.0	+8.0	85	28	71	26	3	49	29	51	44	61	2.04	−1.3	7	5,984	s.	26	w.	28	10	11	9	4.9	...	...
Hannibal	534	74	109	29.47	30.04	+.06	61.0	+7.4	84	25	71	30	3	51	31	...	...	...	2.06	−1.2	8	6,695	sw.	32	se.	4	11	13	6	4.3	T.	...
St. Louis	567	265	303	29.44	30.04	+.06	63.2	+7.1	86	27	73	30	3	54	25	52	44	57	1.20	−2.3	8	9,782	s.	50	s.	8	18	8	4	3.5	T.	...
Missouri Valley.							**58.6**	**+8.2**										**67**	**2.45**	**−0.4**										**4.6**		
Columbia, Mo	781	11	84	29.20	30.03	+0.05	62.0	+7.7	86	23	73	28	3	51	33	...	...	...	2.04	−1.7	8	5,772	se.	40	nw.	10	12	8	10	5.2	...	...
Kansas City	963	161	181	28.97	30.00	+.04	62.2	+7.9	86	28	71	31	1	53	30	52	45	60	2.33	−1.0	9	7,677	s.	38	n.	10	11	11	8	4.8	T.	...
St. Joseph	967	11	49	28.96	30.00	...	61.6	...	90	28	72	29	3	51	31	52	45	64	2.05	...	12	5,946	s.	37	nw.	10	10	11	9	4.8	...	...
Springfield, Mo	1,324	98	104	28.63	30.03	+.06	61.8	+6.1	84	28	71	29	1	53	28	52	46	62	2.78	−1.1	10	7,873	se.	42	nw.	29	20	7	3	2.9	T.	...
Iola	984	11	50	28.95	30.00	+.05	61.0	+6.8	84	27	72	24	3	50	34	...	...	...	5.56	+2.8	12	5,011	s.	32	s.	4	12	11	7	4.1	...	...
Topeka	983	85	101	...	...	...	61.0	+7.3	89	28	72	29	3	50	34	...	...	...	3.10	+0.4	11	6,980	s.	36	s.	26	11	10	9	4.7	...	...
Lincoln	1,189	11	84	28.70	29.96	+.02	59.3	+8.6	90	28	70	25	1	48	34	50	45	68	1.37	−1.4	10	7,410	s.	42	nw.	10	13	11	6	4.3	...	...
Omaha	1,105	115	121	28.80	29.98	+.03	60.0	+9.5	88	28	70	26	1	50	30	52	46	67	0.81	−2.2	10	5,698	nw.	31	nw.	10	15	8	7	4.6	...	...
Valentine	2,598	47	54	27.24	29.95	+.01	52.2	+6.8	82	27	64	14	2	40	45	46	41	74	3.46	+1.1	9	7,896	w.	40	sw.	17	6	15	9	6.0	...	...
Sioux City	1,135	94	164	28.76	29.97	+.02	58.1	+9.6	84	28	69	24	1	47	32	50	44	66	1.16	−1.6	13	9,314	s.	42	nw.	10	15	10	5	4.0	...	...
Huron	1,306	59	74	28.57	29.98	+.02	54.4	+9.8	83	14	66	18	1	42	36	48	44	74	1.80	−0.8	9	8,355	se.	40	nw.	10	11	14	5	4.4	...	...
Pierre	1,572	70	75	28.29	29.96	+.01	54.8	+8.3	86	17	66	15	1	44	35	46	39	64	2.63	+0.6	7	7,449	se.	48	nw.	10	11	11	8	4.9	...	...
Yankton	1,233	49	57	28.65	29.96	+.01	56.9	+9.5	83	22	68	20	1	46	33	...	...	...	2.37	−0.4	8	6,305	w.	29	s.	23	10	12	8	5.4	...	...

TABLE I.—*Climatological data for United States Weather Bureau stations, April, 1915*—Continued.

Districts and stations.	Elevation of instruments: Barometer above sea level, feet.	Elevation of instruments: Thermometer above ground.	Elevation of instruments: Anemometer above ground.	Pressure in inches: Station, reduced to mean of 24 hours.	Pressure in inches: Sea level, reduced to mean of 24 hours.	Pressure in inches: Departure from normal.	Temperature of the air, in degrees Fahrenheit: Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity, per cent.	Precipitation, inches: Total.	Precipitation: Departure from normal.	Days with 0.01 or more.	Wind: Total movement, miles.	Wind: Prevailing direction.	Maximum velocity: Miles per hour.	Maximum velocity: Direction.	Maximum velocity: Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.
Northern Slope.							**51.3**	**+ 8.5**										**62**	**2.10**	**+ 0.5**										**5.2**		
Havre	2,505	11	44	27.26	29.87	−0.06	53.6	+10.9	82	29	68	28	1	39	45	45	36	59	0.24	− 0.8	2	6,562	e.	38	se.	30	16	12	2	3.6	.....	....
Helena	4,110	87	114	25.73	29.90	− .07	51.8	+ 9.8	77	28	63	32	5	41	35	42	34	57	0.93	− 0.2	7	5,952	sw.	45	sw.	13	9	14	7	5.2	0.1	....
Kalispell	2,962	11	34	26.86	29.89	− .07	49.2	+ 6.7	80	29	62	26	9	36	38	41	35	64	1.16	+ 0.1	10	3,430	w.	22	sw.	20	8	16	6	5.0	.....	....
Miles City	2,371	26	48	27.40	29.94	− .02	56.8	+12.1	89	13	70	28	11	44	38	46	37	57	0.68	− 0.5	2	4,525	n.	30	nw.	10	9	16	5	4.4	.....	....
Rapid City	3,259	50	58	26.55	29.96	+ .01	52.8	+ 9.3	80	14	63	27	2	42	40	44	36	57	2.81	+ 0.5	12	6,712	n.	37	n.	10	8	12	10	6.0	T.	....
Cheyenne	6,088	84	101	23.96	29.92	+ .01	46.0	+ 4.4	70	27	56	26	1	36	36	39	34	71	3.29	+ 1.4	12	8,492	nw.	44	nw.	4	3	15	12	6.9	T.	....
Lander	5,372	60	68	24.58	29.90	− .04	51.1	+ 8.9	77	28	64	31	2	39	42	41	31	54	1.39	− 1.1	11	3,755	sw.	27	w.	29	6	14	10	5.7	.....	....
Sheridan	3,790	10	47	26.04	29.92	......	52.0	......	84	29	65	27	11	39	46	44	36	62	1.79	......	10	5,104	se.	34	se.	29	7	12	11	5.5	.....	....
Yellowstone Park	6,200	11	48	23.82	29.91	− .05	45.0	+ 8.0	71	28	57	23	9	33	36	37	32	67	1.29	− 0.1	12	4,535	s.	29	sw.	20	7	16	7	5.4	T.	....
North Platte	2,821	11	51	27.05	29.97	+ .05	55.0	+ 6.0	83	27	67	26	2	43	45	47	41	70	7.10	+ 5.0	10	6,026	s.	38	n.	10	14	8	8	4.8	T.	....
Middle Slope.							**57.8**	**+ 4.1**										**67**	**3.71**	**+ 1.5**										**5.6**		
Denver	5,291	129	172	24.67	29.90	.00	51.4	+ 3.7	77	27	62	28	1	41	34	44	38	66	3.66	+ 1.5	11	5,732	sw.	40	nw.	4	5	14	11	6.4	T.	....
Pueblo	4,685	80	86	25.22	29.89	+ .01	53.4	+ 2.9	80	27	66	26	1	41	39	43	35	59	3.07	+ 1.6	11	4,442	nw.	34	nw.	4	6	14	10	6.2	T.	....
Concordia	1,398	42	50	28.50	29.97	+ .04	59.6	+ 6.0	91	28	71	27	2	49	35	52	47	70	2.47	0.0	5	5,684	s.	23	s.	4	7	12	11	6.0	.....	....
Dodge	2,509	11	51	27.35	29.94	+ .04	58.8	+ 4.4	89	28	71	29	2	47	35	50	44	69	2.28	+ 0.4	9	8,211	s.	34	s.	13	11	13	6	4.9	T.	....
Wichita	1,358	139	158	28.52	29.94	+ .01	60.8	+ 4.2	83	27	70	29	2	51	34	53	47	68	3.29	+ 0.6	8	9,506	s.	47	nw.	4	14	6	10	4.7	.....	....
Oklahoma	1,214	10	47	28.70	29.97	+ .05	63.0	+ 3.4	85	29	72	31	3	54	32	54	49	68	7.50	+ 4.7	8	10,577	s.	46	s.	4	7	18	5	5.4	.....	....
Southern Slope.							**61.6**	**− 0.8**										**67**	**5.64**	**+ 4.0**										**5.5**		
Abilene	1,738	10	52	28.15	29.95	+ .05	64.0	− 0.4	85	21	75	32	2	53	36	56	50	68	8.06	+ 5.8	13	7,965	se.	40	sw.	4	5	14	11	6.2	.....	....
Amarillo	3,676	10	49	26.21	29.92	+ .05	57.0	+ 2.4	88	28	69	29	1	45	38	49	44	71	5.05	+ 3.3	15	7,997	s.	46	sw.	6	13	11	6	4.4	1.7	....
Del Rio	944	64	71	28.94	29.92	+ .03	67.2	− 2.8	86	9	75	40	2	60	30	......	......	......	3.39	+ 1.4	15	7,761	se.	38	nw.	25	9	9	12	6.0	.....	....
Roswell	3,566	75	85	26.29	29.88	+ .03	58.0	− 2.6	83	27	71	29	2	45	45	48	40	61	6.04	+ 5.6	13	5,899	s.	60	se.	16	6	17	7	5.3	T.	....
Southern Plateau.							**57.0**	**− 0.8**										**49**	**1.28**	**+ 0.9**										**3.8**		
El Paso	3,762	110	133	26.11	29.83	.00	62.7	− 1.1	85	27	75	39	1	50	34	48	34	42	0.20	0.0	5	9,087	w.	48	nw.	24	12	15	3	3.7	.....	....
Santa Fe	7,013	57	62	23.19	29.87	+ .03	47.7	+ 0.1	71	28	58	31	1	37	30	39	31	62	4.82	+ 4.0	14	4,787	sw.	48	s.	29	4	18	8	5.9	1.9	....
Flagstaff	6,908	8	57	23.26	29.82	− .02	42.4	+ 0.2	66	11	55	20	15	30	41	......	......	......	3.60	......	11	......	sw.	39	sw.	5	7	17	6	....	19.5	14.0
Phoenix	1,108	76	81	28.69	29.84	− .03	66.4	− 0.2	91	12	79	44	30	53	34	53	41	46	0.88	+ 0.4	5	4,022	e.	33	w.	30	15	9	6	3.7	.....	....
Yuma	141	9	58	29.69	29.84	− .05	69.0	− 1.1	97	12	84	47	30	54	44	55	43	46	0.08	0.0	1	4,545	w.	31	nw.	13	26	3	1	1.0	.....	....
Independence	3,910	11	42	25.85	29.80	− .10	53.8	− 2.9	80	17	67	31	30	40	38	......	......	......	0.44	+ 0.3	4	5,735	se.	32	nw.	4	11	14	5	4.8	.....	....
Middle Plateau.							**52.3**	**+ 3.4**										**56**	**1.93**	**+ 0.8**										**5.7**		
Reno	4,532	74	81	25.38	29.88	−0.09	50.1	+ 2.8	77	16	63	26	30	37	40	40	30	55	0.33	− 0.3	7	5,506	w.	36	se.	28	9	8	13	5.7	0.2	0.2
Tonopah	6,090	12	20	23.95	29.84	......	46.6	......	70	12	56	19	30	38	30	39	30	59	3.26	+ 1.6	11	7,352	se.	35	nw.	14	12	8	10	5.5	21.5	14.0
Winnemucca	4,344	18	56	25.52	29.88	− .08	50.4	+ 3.3	79	28	64	26	30	36	43	41	33	60	2.33	+ 1.4	11	4,687	ne.	31	s.	20	9	8	13	5.7	5.0	1.2
Modena	5,479	10	43	24.52	29.84	− .04	48.2	+ 1.3	72	12	62	26	30	34	42	38	28	55	2.38	+ 1.6	13	7,797	sw.	56	s.	21	7	7	16	6.4	1.6	T.
Salt Lake City	4,360	147	189	25.51	29.84	− .08	56.4	+ 6.3	83	28	67	33	30	46	30	45	37	54	1.88	− 0.4	8	5,864	se.	56	nw.	3	9	12	9	5.3	.....	....
Grand Junction	4,602	82	96	25.28	29.83	− .05	56.4	+ 3.2	79	28	68	34	1	45	33	44	33	50	1.41	+ 0.6	11	5,741	se.	42	se.	13	8	15	7	5.4	.....	....
Northern Plateau.							**53.9**	**+ 5.0**										**55**	**1.62**	**+ 0.2**										**5.5**		
Baker	3,471	48	53	26.39	29.97	− .03	49.4	+ 5.9	81	28	63	28	30	36	43	40	30	54	1.59	+ 0.6	6	5,048	n.	22	nw.	14	9	13	8	5.2	1.4	T.
Boise	2,739	78	86	27.07	29.91	− .07	55.3	+ 5.2	84	28	68	32	30	43	40	45	34	51	1.05	− 0.1	9	4,013	nw.	34	se.	29	10	4	16	6.2	1.8	T.
Lewiston	757	40	48	29.14	29.95	− .04	56.8	+ 3.9	87	28	69	35	9	44	43	......	......	......	1.75	+ 0.6	12	2,265	e.	28	nw.	20	10	7	13	5.6	.....	....
Pocatello	4,477	46	54	25.38	29.86	− .08	52.4	+ 5.6	78	28	65	33	24	40	36	43	34	56	1.51	− 0.5	9	5,210	se.	30	sw.	13	9	12	9	5.6	.....	....
Spokane	1,929	101	110	27.90	29.94	− .05	52.8	+ 5.1	78	18	64	31	9	41	35	44	36	59	1.46	+ 0.2	9	4,281	sw.	26	s.	2	8	12	10	5.8	T.	....
Walla Walla	1,000	57	65	28.86	29.94	− .07	56.9	+ 4.1	82	19	68	36	29	46	33	48	38	55	2.35	+ 0.6	11	3,414	s.	20	w.	2	13	11	6	4.7	T.	....
North Pacific Coast Region.							**51.6**	**+ 3.2**										**77**	**2.70**	**− 0.6**										**5.3**		
North Head	211	11	56	29.82	30.05	.00	49.8	+ 2.3	72	15	53	42	30	47	22	48	46	88	2.58	− 0.6	10	13,222	nw.	68	nw.	29	10	8	12	5.8	.....	....
Port Crescent	259	8	53	29.75	30.03	+ .01	46.6	+ 1.9	66	15	55	30	21	38	32	......	......	......	1.44	− 1.1	8	3,789	s.	15	n.	30	7	16	7	5.4	.....	....
Seattle	125	215	250	29.90	30.03	.00	52.6	+ 3.2	74	16	60	37	30	45	26	49	46	79	2.91	+ 0.2	10	5,730	se.	40	sw.	7	7	10	13	6.0	.....	....
Tacoma	213	113	120	29.80	30.03	.00	52.3	+ 3.4	75	16	61	35	30	44	29	47	42	71	2.65	− 0.1	9	3,775	n.	28	sw.	12	8	12	10	5.6	.....	....
Tatoosh Island	109	7	57	29.91	30.01	+ .01	49.8	+ 3.7	61	15	54	41	7	46	15	47	44	84	5.92	− 0.4	11	10,679	s.	79	sw.	7	12	5	13	5.3	.....	....
Portland, Oreg.	153	68	106	29.85	30.00	− .06	55.6	+ 4.4	82	16	66	37	21	46	32	49	44	69	2.03	− 1.0	13	4,248	nw.	32	nw.	29	12	11	7	4.4	.....	....
Roseburg	510	9	57	29.46	30.02	− .05	54.4	+ 3.5	83	16	66	34	14	42	43	48	42	70	1.38	− 1.1	12	2,234	n.	20	n.	29	10	16	4	4.5	.....	....
Middle Pacific Coast Region.							**55.1**	**+ 1.6**										**73**	**1.06**	**− 1.0**										**5.8**		
Eureka	62	73	89	29.98	30.05	− .06	52.3	+ 2.8	69	1	57	42	14	48	18	49	46	81	1.38	− 2.6	8	6,573	n.	58	n.	29	7	8	15	6.6	.....	....
Mount Tamalpais	2,375	11	18	27.50	29.98	− .07	49.2	− 0.3	68	15	55	34	30	44	20	44	40	74	1.09	− 0.3	11	12,684	nw.	68	nw.	4	9	6	15	5.8	.....	....
Point Reyes Light	490	7	18	29.43	29.94	......	52.3	+ 3.7	67	1	56	42	30	49	17	......	......	......	1.11	......	7	18,381	nw.	110	nw.	29	7	6	17	6.4	.....	....
Red Bluff	332	50	56	29.58	29.94	− .09	59.8	+ 0.7	86	15	69	40	30	50	31	52	46	67	1.71	− 0.1	6	4,054	nw.	35	nw.	14	11	8	11	5.2	.....	....
Sacramento	69	106	117	29.88	29.94	− .07	58.3	+ 0.3	80	15	67	44	24	50	25	52	46	68	0.50	− 1.5	5	6,350	s.	37	nw.	29	12	14	4	4.9	.....	....
San Francisco	155	209	213	29.82	29.98	− .07	57.1	+ 3.4	74	9	63	48	30	52	22	51	47	74	0.62	− 1.2	6	6,263	sw.	34	nw.	29	10	12	8	5.5	.....	....
San Jose	141	12	110	29.85	30.00	......	57.0	+ 0.3	77	15	66	42	8	48	33	......	......	......	1.07	− 0.3	8	4,427	nw.	44	w.	29	7	12	11	5.9	.....	....
South Pacific Coast Region.							**59.0**	**+ 1.0**										**75**	**1.31**	**+ 0.3**										**6.0**		
Fresno	327	89	98	29.59	29.95	− .04	60.0	− 1.2	84	10	71	40	30	49	32	52	46	64	0.81	+ 0.1	7	5,545	nw.	44	nw.	13	9	10	11	5.5	.....	....
Los Angeles	338	159	191	29.58	29.95	− .04	60.4	+ 2.8	86	10	68	44	30	53	30	54	51	76	0.81	− 0.3	7	4,421	sw.	30	sw.	30	4	13	13	6.8	.....	....
San Diego	87	62	70	29.86	29.95	− .04	59.7	+ 1.5	74	10	65	46	30	54	21	54	51	78	1.15	+ 0.4	9	5,785	w.	46	w.	30	6	14	10	5.7	.....	....
San Luis Obispo	201	32	40	29.79	29.96	− .09	56.0	+ 0.8	79	9	65	39	30	47	31	51	48	82	2.47	+ 1.0	10	3,442	w.	25	w.	30	7	10	13	6.2	.....	....
West Indies.																																
San Juan	82	8	54	29.85	29.93	− .05	76.6	......	90	4	81	69	8	72	17	......	......	......	13.17	+ 9.3	14	11,733	ne.	44	e.	10	6	9	15	6.8	.....	....
Panama.																																
Balboa Heights	118	7	97	29.72	29.85	......	80.5	......	93	1	87	71	30	74	18	75	73	84	5.37	+ 2.5	10	6,724	n.	39	n.	5	1	18	11	7.0	.....	....
Colon	25	5	71	29.83	29.86	......	81.5	......	89	26	86	74	28	78	14	77	75	85	10.42	+ 6.2	18	9,477	n.	46	n.	4	8	15	7	5.4	.....	....

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during April, 1915, at all stations furnished with self-registering gages.*

Stations.	Date.	Total duration.		Total amount of precipitation.	Excessive rate.		Amount before excessive rate began.	Depths of precipitation (in inches) during periods of time indicated.													
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Abilene, Tex.	18-19	8:15 p.m.	D. N. a.m.	1.76	9:17 p.m.	9:55 p.m.	0.06	0.39	0.75	1.04	1.10	1.12	1.18	1.34	1.38						
	19	12:00 noon	1:05 p.m.	0.65	12:31 p.m.	12:56 p.m.	.02	.09	.22	.34	.51	.62									
	21-22	D. N. p.m.	7:45 a.m.	1.01	10:49 p.m.	11:15 p.m.	.08	.12	.24	.37	.42	.49	.52								
	25	D.N. a.m.	8:30 a.m.	1.49	4:14 a.m.	4:39 a.m.	.06	.27	.53	.70	.78	.87									
	29-30	10:40 p.m.	D.N. a.m.	1.09	10:45 p.m.	11:09 p.m.	.01	.08	.24	.41	.47	.55									
Albany, N. Y.	28			0.65														0.43			
Alpena, Mich.	10			0.39														.14			
Amarillo, Tex.	17			1.34														.41			
Anniston, Ala.	2			0.04														.04			
Asheville, N. C.	23			0.35														.26			
Atlanta, Ga.	2			0.22														(*)			
Atlantic City, N. J.	2			1.39														(*)			
Augusta, Ga.	2-3			0.65														.12			
Baker, Oreg.	29			1.01														(*)			
Baltimore, Md.	3			0.65														(*)			
Bentonville, Ark.	9			0.87														(*)			
Binghamton, N. Y.	28	4:40 p.m.	9:10 p.m.	0.89	6:41 p.m.	7:06 p.m.	.04	.24	.47	.54	.59	.65									
Birmingham, Ala.	28	5:57 p.m.	7:07 p.m.	0.65	5:59 p.m.	6:14 p.m.	.01	.34	.50	.56											
Bismarck, N. Dak.	23-24			0.77														.16			
Block Island, R. I.	30			0.50														.26			
Boise, Idaho.	29-30			0.58														(*)			
Boston, Mass.	16			0.40														.22			
Buffalo, N. Y.	11			0.18														.11			
Burlington, Vt.	11			0.20														(*)			
Cairo, Ill.	9-10			0.86														.40			
Canton, N. Y.	11			0.40														(*)			
Charles City, Iowa.	26			1.30														.64			
Charleston, S. C.	2			0.96														.28			
Charlotte, N. C.	11			0.16														.16			
Chattanooga, Tenn.	10			0.93														.39			
Cheyenne, Wyo.	22-23			1.24														.15			
Chicago, Ill.	10			0.58														.19			
Cincinnati, Ohio.	10			0.26														.23			
Cleveland, Ohio.	10			0.37														.14			
Columbia, Mo.	22	11:35 a.m.	12:40 p.m.	0.50	11:42 a.m.	11:56 a.m.	.01	.11	.34	.45											
Columbia, S. C.	2-3			0.89														(*)			
Columbus, Ohio.	10			0.39														.37			
Concord, N. H.	30			1.40														.57			
Concordia, Kans.	24-25			1.67														.41			
Corpus Christi, Tex.	23	8:06 a.m.	11:00 a.m.	1.19	8:52 a.m.	9:27 a.m.	.12	.11	.36	.52	.64	.72	.85	.92							
Davenport, Iowa.	14			0.29														.15			
Dayton, Ohio.	21-22			0.35														.16			
Del Rio, Tex.	25	3:55 a.m.	7:05 a.m.	1.16	6:30 a.m.	6:50 a.m.	.35	.25	.55	.66	.80										
Denver, Colo.	22-23			2.00														.41			
Des Moines, Iowa.	28			0.34														.26			
Detroit, Mich.	11			0.24														.09			
Devils Lake, N. Dak.	23-24			0.75														.16			
Dodge City, Kans.	24-25			0.91														.36			
Dubuque, Iowa.	16			0.07														.07			
Duluth, Minn.	23			0.38														.36			
Eastport, Me.	3-4			1.16														(*)			
Elkins, W. Va.	23			0.63														.24			
El Paso, Tex.	6			0.08														.08			
Erie, Pa.	10			0.47														(*)			
Escanaba, Mich.	23			0.18														.17			
Eureka, Cal.	2			0.38														.15			
Evansville, Ind.	10			0.32														.27			
Flagstaff, Ariz.	21-22			0.97														(*)			
Fort Smith, Ark.	9	1:30 p.m.	4:25 p.m.	2.10	3:21 p.m.	4:16 p.m.	.09	.08	.30	.46	.53	.67	.96	1.25	1.38	1.43	1.60	2.00			
	19	1:09 p.m.	7:55 p.m.	0.66	1:28 p.m.	1:43 p.m.	.01	.23	.33	.40											
Fort Wayne, Ind.	10			0.62														.29			
Fort Worth, Tex.	22-23	7:16 p.m.	7:10 a.m.	1.30	12:26 a.m.	12:47 a.m.	.11	.16	.28	.48	.52										
	25	6:21 p.m.	9:15 p.m.	0.70	7:41 p.m.	7:52 p.m.	.03	.37	.52												
Fresno, Cal.	12			0.28														.28			
Galveston, Tex.	19	11:20 a.m.	12:25 p.m.	0.73	11:33 a.m.	11:46 a.m.	.02	.19	.48	.70											
Grand Haven, Mich.	10			0.32														.11			
Grand Junction, Colo.	15			0.47														.35			
Grand Rapids, Mich.	10			0.36														.16			
Green Bay, Wis.	9			0.47														(*)			
Hannibal, Mo.	8-10			1.51														.40			
Harrisburg, Pa.	27	3:57 p.m.	5:28 p.m.	0.47	4:00 p.m.	4:11 p.m.	.01	.23	.33	.36											
Hartford, Conn.	3			0.77														(*)			
Hatteras, N. C.	2-3	12:25 p.m.	7:44 a.m.	3.24	11:46 p.m.	1:04 a.m.	1.20	.10	.17	.24	.26	.30	.34	.38	.47	.59	.72	.99	1.57		
Havre, Mont.	4			0.22														.09			
Helena, Mont.	13			0.27														.23			
Houghton, Mich.	27			0.57														.26			
Houston, Tex.	19-20			0.95														.38			
Huron, S. Dak.	7-8			0.64														.27			
Independence, Cal.	28			0.36														0.15			
Indianapolis, Ind.	10			0.39														.26			
Iola, Kans.	25-26			1.81														.55			
Jacksonville, Fla.	2			0.44														(*)			
Kalispell, Mont.	30			0.59														.10			
Kansas City, Mo.	9-10			1.11														(*)			
Keokuk, Iowa.	22			0.71														(*)			
Key West, Fla.	2	5:40 a.m.	10:35 a.m.	1.35	6:43 a.m.	7:25 a.m.	0.07	0.09	0.30	0.35	0.37	0.40	0.47	0.64	0.96	1.01					
Knoxville, Tenn.	11			0.92														.29			
La Crosse, Wis.	27			0.25														.09			
Lander, Wyo.	5			0.35														.15			
Lansing, Mich.	11			0.43														.24			
Lewiston, Idaho.	2-3			0.62														.43			
Lexington, Ky.	10-11			0.32														.17			
Lincoln, Nebr.	25			0.51														(*)			
Little Rock, Ark.	9-10	9:02 p.m.	D.N. a.m.	1.97	9:02 p.m.	10:02 p.m.	.00	.12	.34	.41	.51	.60	.64	.68	.70	.70	.71	.99			
Los Angeles, Cal.	26			0.16														.14			
Louisville, Ky.	22			0.62														.44			
Ludington, Mich.	4-5			0.31														(*)			
Lynchburg, Va.	11	1:45 p.m.	2:45 p.m.	0.36	1:58 p.m.	2:07 p.m.	.01	.26	.30												

* Self-register not working.

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during April, 1915, at all stations furnished with self-registering gages*—Continued.

Stations.	Date.	Total duration.		Total amount of precipitation.	Excessive rate.		Amount before excessive rate began.	Depths of precipitation (in inches) during periods of time indicated.													
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Macon, Ga.	28			0.22														0.13			
Madison, Wis.	11–12			0.65														.17			
Marquette, Mich.	4			0.33														(*)			
Memphis, Tenn.	30	5:53 p. m.	8:52 p. m.	0.86	6:47 p. m.	7:21 p. m.	0.04	0.13	0.28	0.30	0.39	0.45	0.54	0.58							
Meridian, Miss.	30			0.40														.20			
Miami, Fla.	2			0.59														.35			
Milwaukee, Wis.	11			0.25														.07			
Minneapolis, Minn.	26–27			0.82														.39			
Mobile, Ala.	29			0.07														.07			
Modena, Utah	28–30			1.25														.31			
Montgomery, Ala.	2			0.20														(*)			
Moorhead, Minn.	22			0.46														(*)			
Mount Tamalpais, Cal.	6–7			0.44														.10			
Nantucket, Mass.	3–4			1.06														(*)			
Nashville, Tenn.	21–22			0.39														.24			
New Haven, Conn.	3			0.80														(*)			
New Orleans, La.	11			0.03														.03			
New York, N. Y.	3			1.13														.15			
Norfolk, Va.	11–12			0.25														.18			
Northfield, Vt.	11			0.39														.17			
North Head, Wash.	31[1]–1			3.20														.20			
North Platte, Nebr.	21–22	9:37 p. m.	D. N. a. m.	1.57	10:00 p. m.	10:47 p. m.	.03	.09	.27	.43	.57	.69	.79	.86	.97	1.05	1.09				
Oklahoma, Okla.	7	2:15 p. m.	5:10 p. m.	0.83	3:13 p. m.	3:38 p. m.	.01	.09	.16	.40	.51	.59									
	22	12:55 p. m.	5:30 p. m.	1.72	2:43 p. m.	3:46 p. m.	.48	.12	.16	.22	.28	.34	.39	.42	0.49	0.58	0.68	1.03	1.19		
	25	1:50 p. m.	7:15 p. m.	1.86	3:41 p. m.	4:46 p. m.	.15	.08	.15	.29	.46	.66	.84	.97	1.02	1.08	1.14	1.43	1.57		
Omaha, Nebr.	20			0.17														.17			
Oswego, N. Y.	11			0.21														(*)			
Palestine, Tex.	23	1:10 p. m.	9:35 p. m.	2.56	5:35 p. m.	6:08 p. m.	1.20	.19	.44	.61	.67	.75	.83	.89							
	26	3:05 a. m.	7:20 a. m.	1.26	5:50 a. m.	6:23 a. m.	.14	.07	.15	.25	.36	.70	.95	1.04							
Parkersburg, W. Va.	22			0.73														.48			
Pensacola, Fla.	29			0.04														.04			
Peoria, Ill.	9–10			0.96														(*)			
Philadelphia, Pa.	11	5:16 p. m.	7:10 p. m.	0.55	5:48 p. m.	6:02 p. m.	.07	.34	.38												
Phoenix, Ariz.	28–29			0.52														.28			
Pierre, S. Dak.	26			1.16														.22			
Pittsburgh, Pa.	25			0.26														.19			
Pocatello, Idaho	20–21			0.59														.24			
Point Reyes Light, Cal.	25			0.79														.19			
Port Huron, Mich.	9			0.20														(*)			
Portland, Me.	30			1.33														.35			
Portland, Oreg.	1–2			1.09														(*)			
Providence, R. I.	30	9:55 p. m.	11:45 p. m.	0.46	10:59 p. m.	11:08 p. m.	.05	.14	.33												
Pueblo, Colo.	6–7			1.02														(*)			
Raleigh, N. C.	2–3			1.75														(*)			
Rapid City, S. Dak.	30			0.98														.19			
Reading, Pa.	10			0.53														.42			
Red Bluff, Cal.	2	3:03 p. m.	3:53 p. m.	0.52	3:40 p. m.	3:50 p. m.	.11	.25	.41												
Reno, Nev.	29–30			0.16														(*)			
Richmond, Va.	2–3			1.30														(*)			
Rochester, N. Y.	11			0.58														(*)			
Roseburg, Oreg.	24–25			0.43														.16			
Roswell, N. Mex.	15–16	8:08 p. m.	9:40 a. m.	2.75	3:05 a. m.	4:14 a. m.	1.00	.12	.31	.71	.99	1.09	1.13	1.15	1.19	1.26	1.31	1.54	1.66		
	16	7:35 p. m.	11:30 p. m.	0.92	8:58 p. m.	9:13 p. m.	0.08	.28	.50	.59											
Sacramento, Cal.	29			0.30														.15			
Saginaw, Mich.	10			0.28														.18			
St. Joseph, Mo.	23	3:16 p. m.	4:25 p. m.	0.78	3:32 p. m.	4:05 p. m.	.03	.11	.13	.29	.52	.60	.66	.71							
St. Louis, Mo.	8–10			0.92														.22			
St. Paul, Minn.	15	5:07 p. m.	6:20 p. m.	1.16	5:31 p. m.	6:08 p. m.	.05	.13	.22	.33	.50	.58	.96	1.10							
Salt Lake City, Utah	7–8			1.19														(*)			
San Antonio, Tex.	18	2:55 a. m.	5:15 a. m.	0.80	3:25 a. m.	3:45 a. m.	.04	.10	.20	.33	.40										
	18	12:50 p. m.	4:17 p. m.	5.50	1:39 p. m.	2:29 p. m.	.13	.07	.34	.56	1.10	1.43	1.81	2.01	2.44	2.56	2.68				
					2:29 p. m.	3:19 p. m.		2.75	2.83	2.88	2.92	3.02	3.11	3.15	3.17	3.25	3.29				
					3:19 p. m.	4:09 p. m.		3.36	3.43	3.59	4.01	4.71	4.95	4.98	5.04	5.16	5.35				
					4:09 p. m.	4:17 p. m.		5.41	5.46												
Do.	22–23	11:10 p. m.	9:40 a. m.	1.51	1:07 a. m.	1:22 a. m.	.10	.37	.52	.57											
	25	8:35 a. m.	12 noon.	1.79	10:05 a. m.	11:23 a. m.	.08	.05	.11	.21	.52	.74	.86	.93	.96	1.00	1.02	1.26	1.63		
San Diego, Cal.	21			0.34														(*)			
Sand Key, Fla.	2	5:50 a. m.	9:15 a. m.	1.67	6:59 a. m.	7:38 a. m.	.18	.11	.36	(*)	(*)	(*)	(*)	(*)	1.27						
Sandusky, Ohio	10			0.12														.10			
San Francisco, Cal.	25–26			0.30														(*)			
San Jose, Cal.	20–21			0.64														.17			
San Luis Obispo, Cal.	23			0.61														.26			
Santa Fe. N. Mex.	5–7			1.49														(*)			
Sault Ste. Marie, Mich.	28			0.27														(*)			
Savannah, Ga.	2–3			0.90														.16			
Scranton, Pa.	10			0.38														.22			
Seattle, Wash.	1–2			1.87														.22			
Sheridan, Wyo.	15			0.57														.23			
Shreveport, La.	20–21	7:30 p.m.	2:00 a.m.	1.12	10:52 p.m.	11:21 p.m.	.57	.08	.12	.18	.27	.39	.53								
	26	7:20 a.m.	4:40 p.m.	2.80	1:42 p.m.	2:08 p.m.	1.89	.05	.22	.44	.54	.64	.67								
	27–28	11:05 p.m.	12:40 a.m.	1.47	11:29 p.m.	12:03 a.m.	.08	.13	.46	.75	1.00	1.16	1.24	1.32							
Sioux City, Iowa	6–8			0.41														(*)			
Spokane, Wash.	29–30			0.97														.11			
Springfield, Ill.	9–10			1.45														.57			
Springfield, Mo.	8–10			1.96														.28			
Syracuse, N. Y.	28			0.32														.27			
Tacoma, Wash.	1–2			1.48														.15			
Tampa, Fla.	2			0.96														.40			
Tatoosh Island, Wash.	31[1]–4			4.62														.26			
Taylor, Tex.	22–23	4:28 p.m.	10:05 a.m.	2.07	5:16 p.m.	6:07 p.m.	.04	.05	.14	.26	.50	.80	1.14	1.64	1.81	1.93	2.02	2.07			
				7.77	8:18 p.m.	9:08 p.m.	2.46	.07	.14	.18	.22	.32	.38	.44	.67	.74	.93				
					9:08 p.m.	9:58 p.m.		1.10	1.29	1.53	1.68	1.86	2.08	2.25	2.37	2.45	2.56				
					9:58 p.m.	10:48 p.m.		2.63	2.68	2.73	2.81	3.06	3.39	3.77	4.21	4.44	4.61				
					10:48 p.m.	11:38 p.m.		4.66	4.77	4.91	5.03	5.20	5.32	5.42	5.45	5.49	5.53				
					11:38 p.m.	12:42 a.m.		5.58	5.66	5.74	5.78	5.85	5.87	5.87	5.87	5.89	5.95				
Do.	24–25	7:30 p.m.	D.N. a.m.	1.98	9:03 p.m.	10:16 p.m.	.35	.08	.18	.35	.51	.72	.88	1.05	1.11	1.13	1.16	1.23	1.51		
	25	7:24 a.m.	3:40 p.m.	1.90	2:34 p.m.	2:47 p.m.	1.23	.20	.48	.65											
Terre Haute, Ind.	9	6:02 p.m.	7:05 p.m.	0.36	6:21 p.m.	6:31 p.m.	.01	.19	.32												

[1] March 31.

* Self-register not working.

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during April, 1915, at all stations furnished with self-registering gages*—Concluded.

Stations.	Date.	Total duration. From—	Total duration. To—	Total amount of precipitation.	Excessive rate. Began—	Excessive rate. Ended—	Amount before excessive rate began.	5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Thomasville, Ga.	28			0.26														0.21			
Toledo, Ohio	20			0.25														.24			
Tonopah, Nev.	28–30			2.48														(*)			
Topeka, Kans.	25–26			1.28														.53			
Valentine, Nebr.	6–9			2.14														.23			
Vicksburg, Miss.	10	5:29 p.m.	11:30 p.m.	1.16	7:27 p.m.	7:57 p.m.	0.11	0.05	0.10	0.18	0.39	0.62	0.75								
Walla Walla, Wash.	29			1.57														.27			
Washington, D. C.	3			0.44														(*)			
Wichita, Kans.	25			1.32														.33			
Williston, N. Dak.	24			0.33														.07			
Wilmington, N. C.	2–3			1.62														.30			
Winnemucca, Nev.	29–30			1.03														(*)			
Wytheville, Va.	29			0.15														.15			
Yankton, S. Dak.	6–9			1.07														.27			
Yellowstone Park, Wyo.	20–22			0.41														(*)			

* Self-register not working.

TABLE III.—*Data furnished by the Canadian Meteorological Service, April, 1915.*

Stations.	Pressure. Station reduced to mean of 24 hours.	Pressure. Sea-level reduced to mean of 24 hours.	Pressure. Departure from normal.	Temperature. Mean max.+mean min.÷2.	Temperature. Departure from normal.	Temperature. Mean maximum.	Temperature. Mean minimum.	Temperature. Highest.	Temperature. Lowest.	Precipitation. Total.	Precipitation. Departure from normal.	Precipitation. Total snowfall.
	Inches.	*Inches.*	*Inches.*	*°F.*	*°F.*	*°F.*	*°F.*	*°F.*	*°F.*	*Inches.*	*Inches.*	*Inches.*
St. Johns, N. F.	29.83	29.97	+0.08	38.8	+ 4.3	45.5	31.2	65	15	1.48	−2.68	2.0
Sydney, C. B. I.	29.98	30.02	+ .13	38.2	+ 3.2	46.3	30.2	61	19	4.09	+0.14	3.5
Halifax, N. S.	29.92	30.03	+ .07	41.0	+ 3.2	48.9	33.2	70	26	5.86	+1.68	5.7
Yarmouth, N. S.	29.94	30.01	+ .05	40.8	+ 1.9	46.6	35.1	56	26	2.54	−0.85	3.7
Charlottetown, P. E. I.	29.98	30.02	+ .12	37.0	+ 1.8	43.8	30.2	58	21	2.14	−0.51	4.2
Chatham, N. B.	30.03	30.05	+ .15	38.7	+ 3.2	46.9	30.5	60	16	3.53	+0.90	8.2
Father Point, Que.	29.99	30.01	+ .08	35.0	+ 1.8	40.1	29.7	54	12	1.83	+0.25	0.1
Quebec, Que.	29.68	30.01	+ .02	41.2	+ 6.1	49.7	32.8	68	20	1.94	−0.15	T.
Montreal, Que.	29.80	30.01	+ .01	48.1	+ 8.4	57.0	39.2	82	28	1.44	−0.80	T.
Stonecliffe, Ont.	29.42	30.03	+ .01	47.2	+ 9.3	60.5	33.8	88	15	0.96	−0.60	0.1
Ottawa, Ont.	29.75	30.08	+ .06	49.0	+ 9.0	59.2	38.8	86	26	1.21	−0.29	T.
Kingston, Ont.	29.73	30.06	+ .04	46.3	+ 6.3	55.2	37.4	72	26	1.13	−0.66	0.6
Toronto, Ont.	29.64	30.02	.00	49.8	+ 9.0	59.3	40.3	84	26	1.28	−1.09	0.5
White River, Ont.	28.66	29.99	− .05	40.6	+ 7.6	54.4	26.9	78	− 2	1.50	+0.25	T.
Port Stanley, Ont.	29.42	30.06	+ .04	45.6	+ 4.6	54.4	36.9	81	23	1.25	−1.22	0.4
Southampton, Ont.	29.34			46.9	+ 8.2	55.9	37.9	81	23	1.29	−0.51	T.
Parry Sound, Ont.	29.33	30.04	+ .02	45.6	+ 8.0	57.6	33.7	83	11	1.82	−0.09	0.2
Port Arthur, Ont.	29.27	29.98	− .05	43.2	+ 9.7	52.9	33.5	77	16	0.77	−0.95	0.0
Winnipeg, Man.	29.12	29.95	− .07	48.9	+13.0	61.3	36.5	84	19	1.31	+0.26	T.
Minnedosa, Man.	28.12	29.94	− .07	47.4	+11.4	62.1	32.7	85	13	0.77	−0.29	T.
Qu'Appelle, Sask.	27.64	29.98	− .01	49.3	+11.9	64.1	34.4	83	15	0.53	−0.52	T.
Medicine Hat, Alberta	27.56	29.83	− .09	55.4	+10.9	71.3	39.5	87	29	T.	−0.74	0.0
Swift Current, Sask.	27.31	29.86	− .10	51.7	+10.4	67.3	36.0	84	23	T.	−0.93	0.0
Calgary, Alberta	26.30	29.82	− .08	49.2	+ 9.6	64.8	33.7	77	24	0.46	−0.18	0.0
Banff, Alberta	25.30	29.88	− .02	44.4	+ 9.1	58.1	30.6	69	19	1.00	−0.08	0.8
Edmonton, Alberta	27.54	29.81	− .08	48.8	+ 8.9	62.9	34.6	79	23	0.92	+0.04	5.4
Prince Albert, Sask.	28.29	29.85	− .13	46.8	+10.7	58.2	35.2	76	14	0.37	−0.46	0.0
Battleford, Sask.	28.14	29.86	− .11	51.5	+14.3	66.5	36.6	80	20	0.68	+0.21	0.0
Kamloops, B. C.	28.68	29.96	+ .03	55.9	+ 7.0	69.0	42.8	80	33	0.17	−0.22	0.0
Victoria, B. C.	29.74	29.99	− .02	51.2	+ 4.4	58.4	43.9	67	39	0.57	−1.80	0.0
Barkerville, B. C.	25.52	29.81	− .05	40.4	+ 7.3	51.5	29.4	62	22	2.62	+0.80	11.2
Hamilton, Bermuda	29.94	30.11	+ .06	62.6	− 1.3	68.6	56.7	74	53	2.36	−1.72	0.0

Chart I. Hydrographs of Several Principal Rivers, April, 1915.

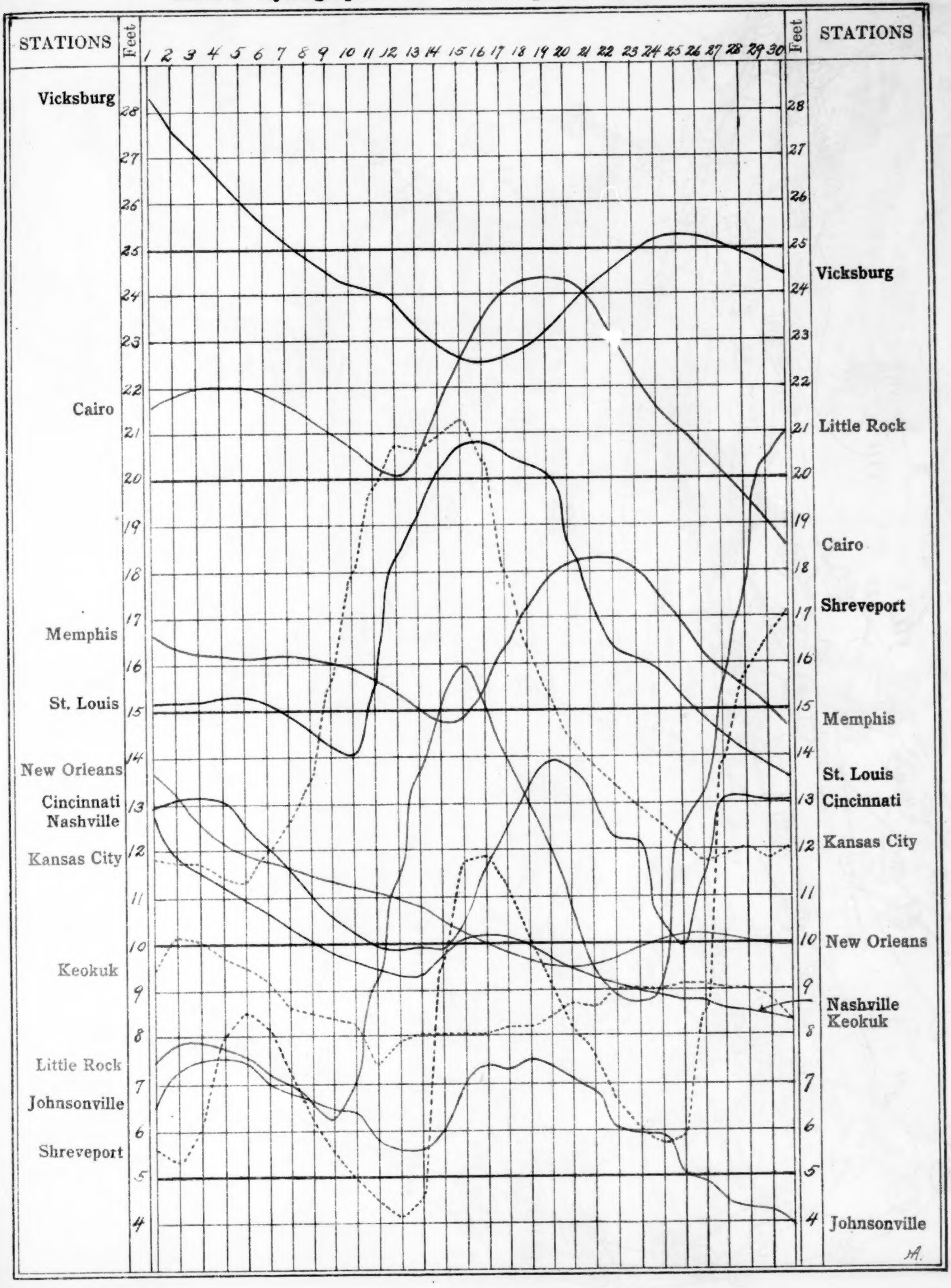

Chart II. Tracks of Centers of High Areas, April, 1915.

(Plotted in Forecast Division.)

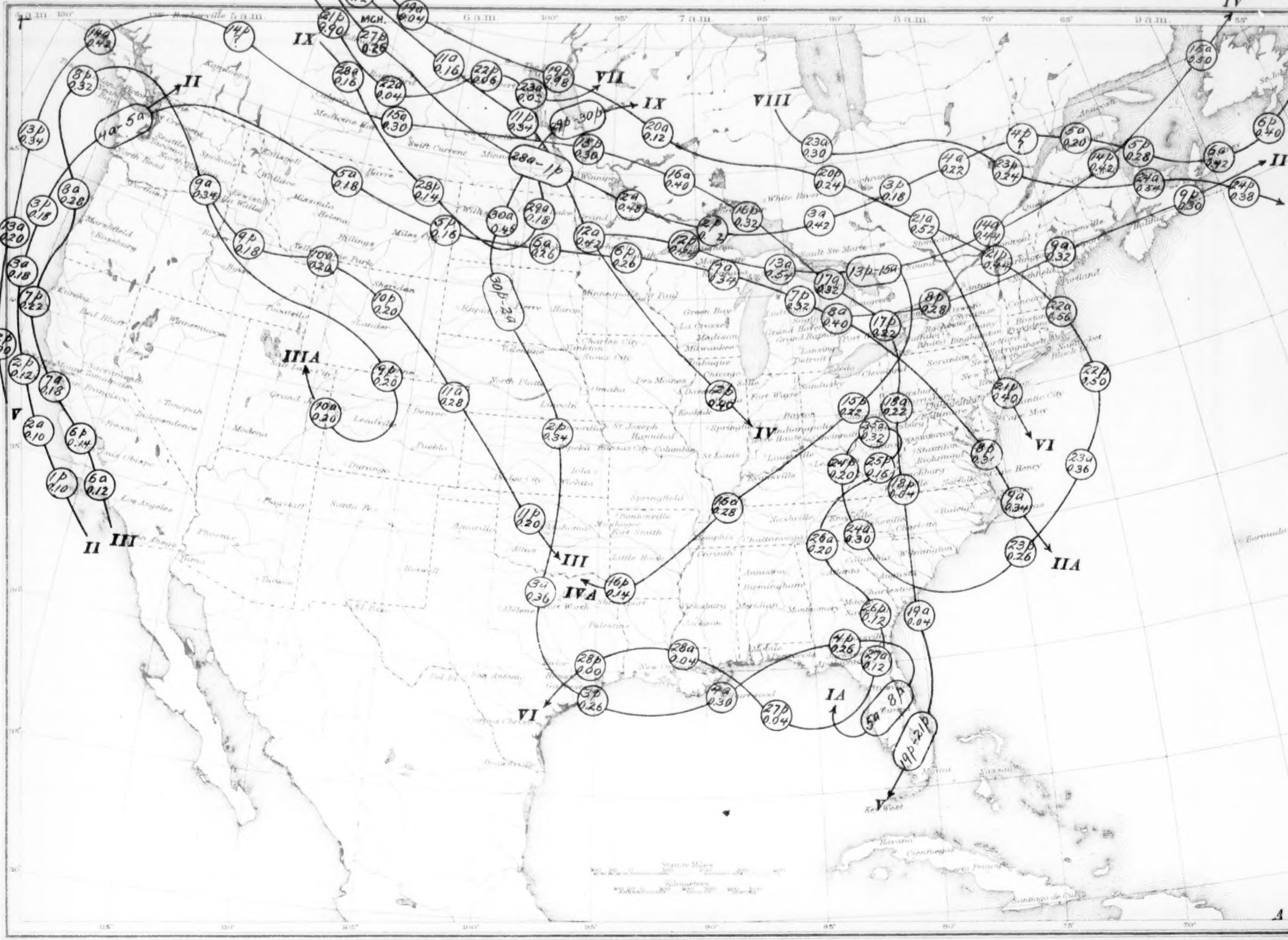

Chart III. Tracks of Centers of Low Areas, April, 1915.

Chart III. Tracks of Centers of Low Areas, April, 1915.

(Plotted in Forecast Division.)

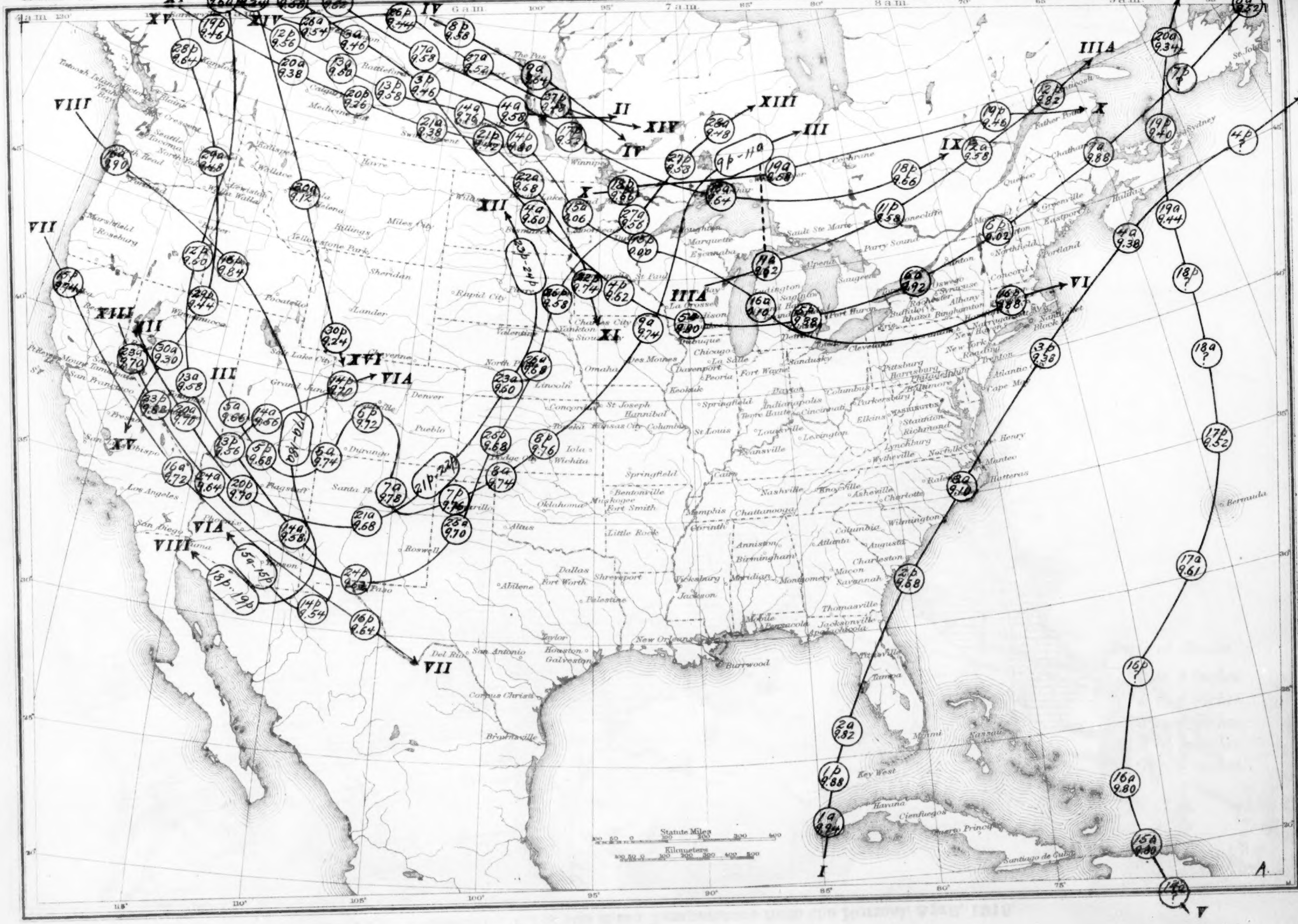

Chart IV. Departure (°F.) of the Mean Temperature from the Normal, April, 1915.

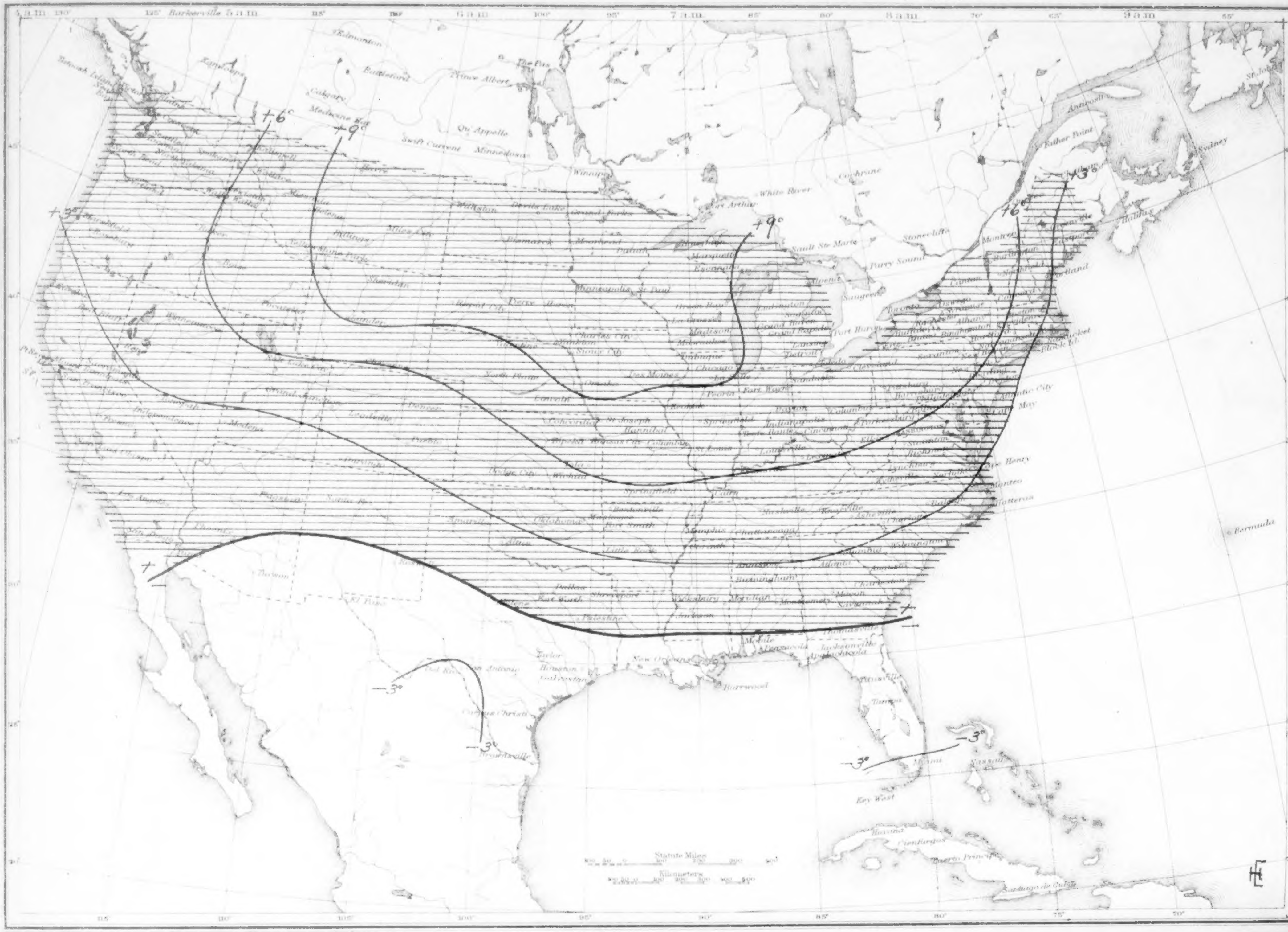

Chart V. Total Precipitation, Inches, April, 1915.

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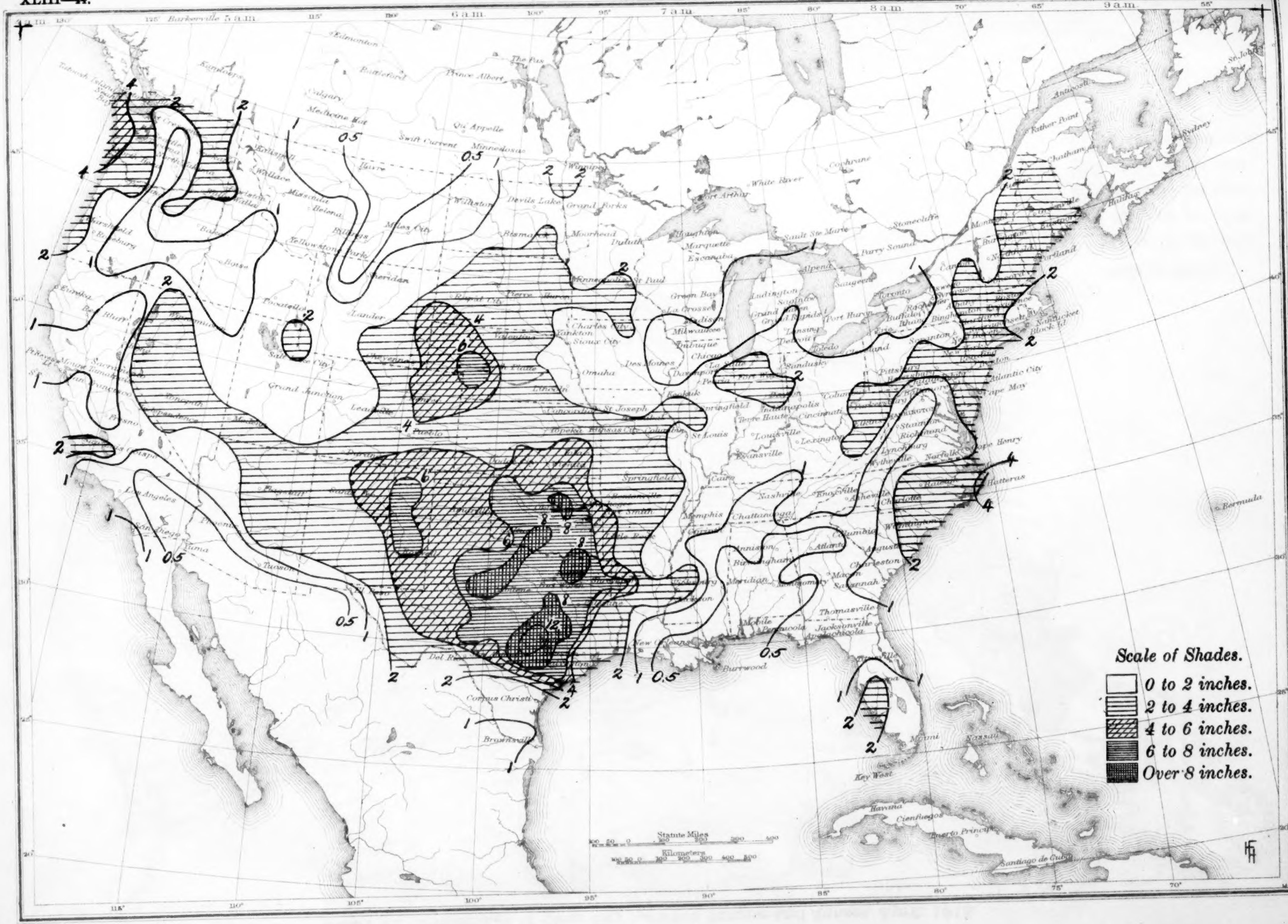

Chart VI. Percentage of Clear Sky between Sunrise and Sunset, April, 1915.

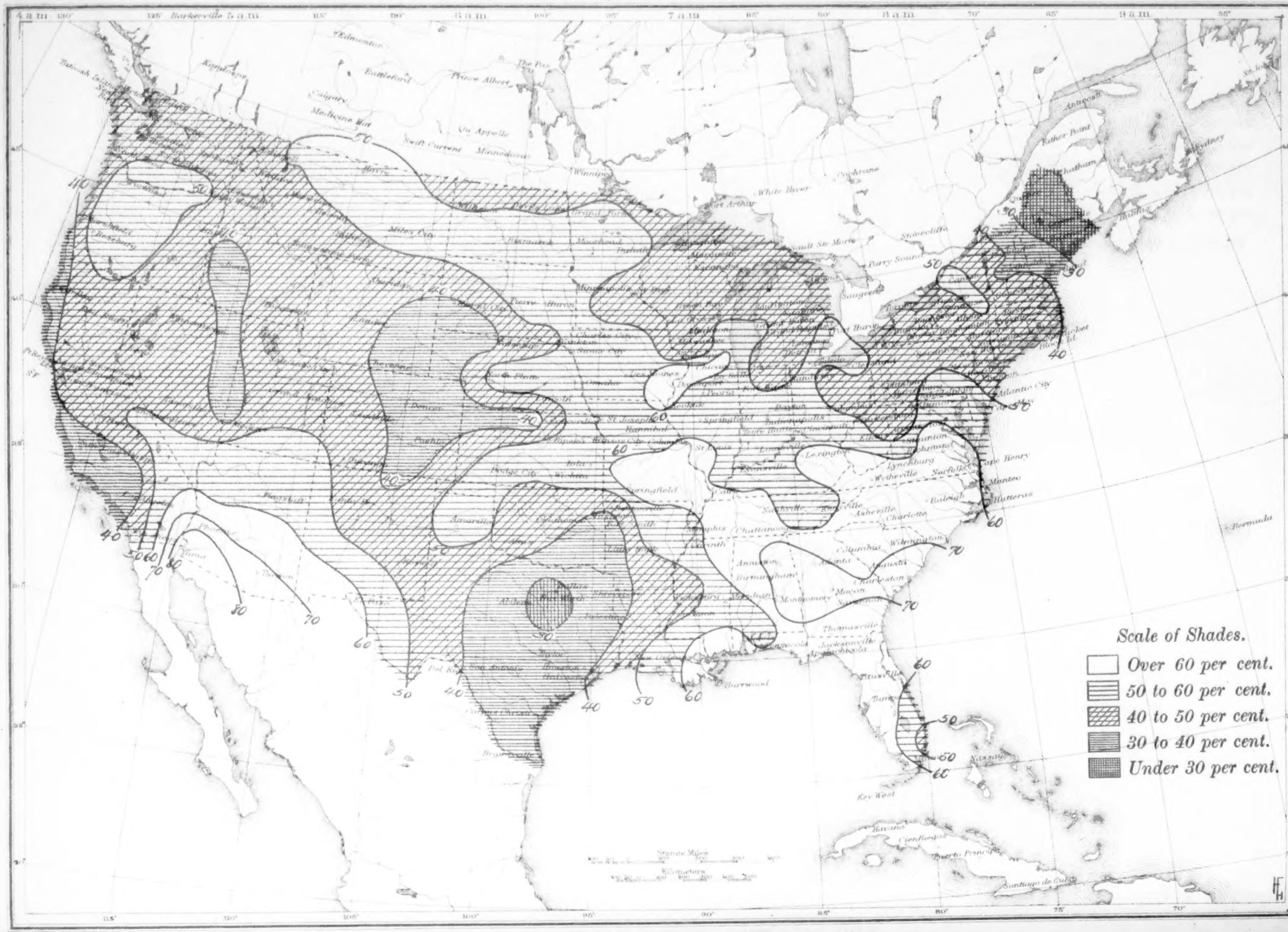

Chart VII. Isobars and Isotherms at Sea Level; Prevailing Winds, April, 1915.

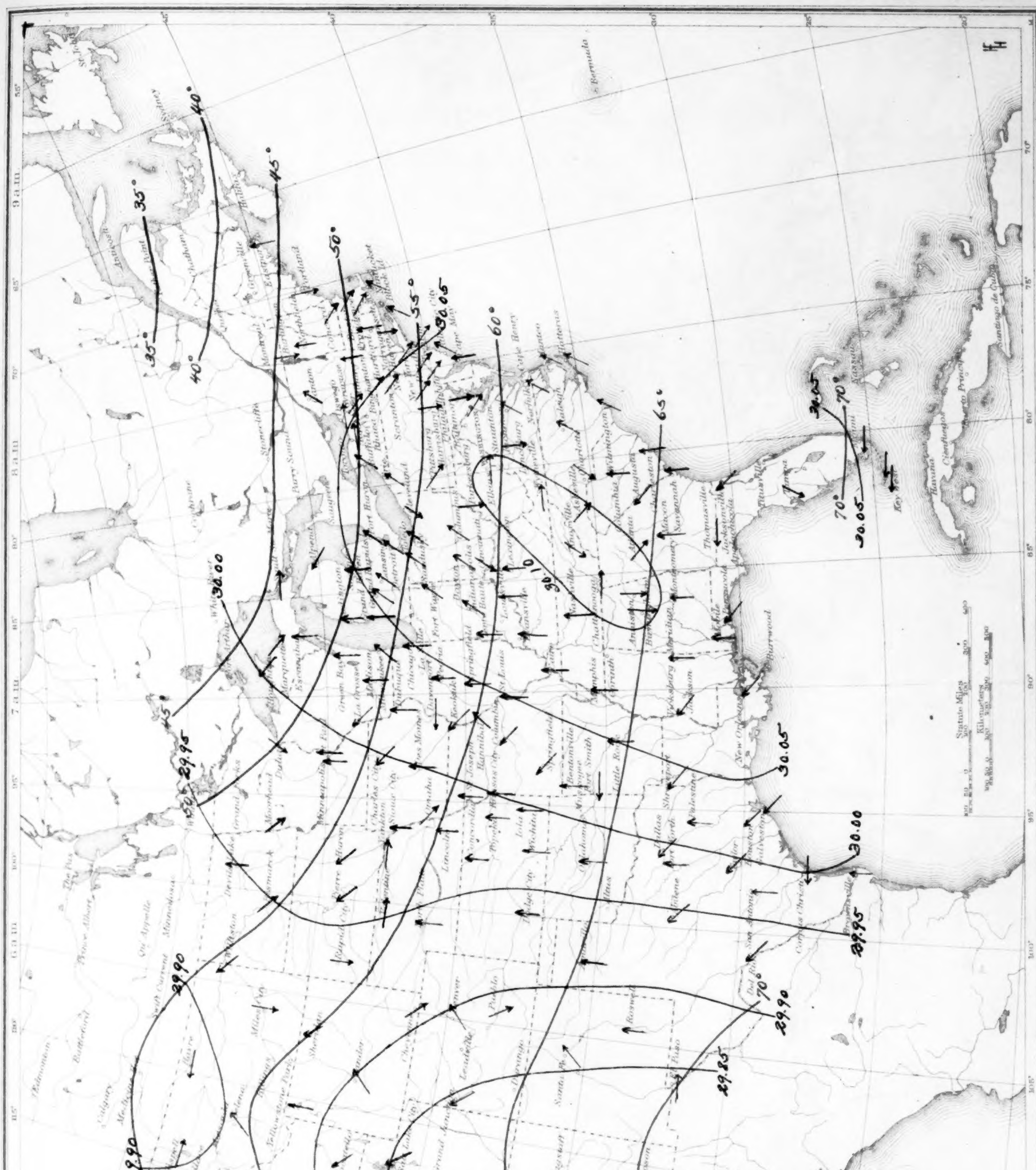

Chart VIII. Total Snowfall, Inches, April, 1915.